Chapter 2 Dolly Varden Char

Results

Relative Abundance and Distribution

The following discussions of relative abundance and distribution of Dolly Varden char result from two separate analyses of the spatial and temporal variation in catch rates (fish/d). In the first analysis we used a two-way ANOVA that addressed the overall contribution of years and sampling areas as sources of variation in CPUE over the 4-year study period. The second set of analyses addressed the spatial and intra-seasonal variation observed in catch rates of Dolly Varden char within each sampling year.

Two-way ANOVA.— From 1988 to 1991, the annual variation in Dolly Varden char relative abundance, as indexed by CPUE, was greater than was the spatial variation observed between the four sampling sites. We determined that year, area, and the interaction effect were all highly significant in the two-way analysis; however, the main effect for YEAR accounted for the most variation in terms of model sum of squares (Table 2.1). Changing the order of entry of the independent variables into the computer algorithm did not change this result.

Interpretation of the pairwise comparisons for the separate main effects (year and area) was invalidated by a significant interaction term. Comparisons among the year × area interaction levels, however, suggest that Dolly Varden char were generally most abundant at all study sites in 1991. This result is corroborated in the one-way ANOVA (see Temporal differences section).

Spatial differences.— Within-year comparisons of daily catch rates among net stations indicated spatial variability in Dolly Varden char abundance (Table 2.2; Figure 2.1). Catch rates differed between the eastern most and western most locations. In 1988, net station SC01 had higher daily catch rates than net station PB02. This pattern was repeated in 1990 and 1991 with net station SC01 daily catch rates being higher than those at net stations BL02 and BL04. These differences are also apparent in the comparisons of daily catch rates among sampling areas. Simpson Cove had higher daily catch rates than Pokok Bay in 1988, and Beaufort Lagoon in 1990 and 1991 (Table 2.3; Figure 2.2). In 1989 this difference was reversed with Simpson Cove catch rates being lower than those in Kaktovik and Jago lagoons.

Temporal differences.— We observed differences in Dolly Varden char daily catch rates between time periods within each year. Daily catch rates at net station SC01 were stable during the open-water seasons of 1988 and 1989 (Table 2.4; Figures 2.3-2.6). In 1990 net station SC01 daily catch rates decreased during early September. During 1991 daily catch rates at net station SC01 were low during early August and appeared to start to decrease again during early September. At net station SC04 daily catch rates were stable during the 1989 open-water season. During 1990 daily catch rates declined towards the

TABLE 2.1.– Two factor analysis of variance on log-transformed catch rates (ln (CPUE+1)) and Tukey means comparisons for Dolly Varden char from coastal waters of the Arctic Refuge. Effects followed by the same letter are not significantly different ($P > 0.05$). $Mean_g$ = geometric mean.

Source	df	Sum of squares	Mean square	*F*-value	*P*-value
Model					
Year	3	367.71	122.57	123.60	0.0001
Area	3	102.31	34.10	34.39	0.0001
Year×Area	7	99.73	14.25	14.37	0.0001
Error	1281	1270.38	0.99		
Total	1294	1840.14			

Year	$Mean_g$	Tukey grouping
1991	2.71	A
1988	1.90	B
1989	1.62	C
1990	1.43	C

Area	$Mean_g$	Tukey grouping
Simpson	2.09	A
Kaktovik	2.04	A B
Jago	1.84	B
Beaufort	1.51	C

Year×Area	$Mean_g$	Tukey grouping
1991-Simpson	3.37	A
1991-Kaktovik	2.78	B
1991-Beaufort	2.44	B C
1991-Jago	2.32	B C D
1988-Kaktovik	2.06	E C D
1990-Simpson	2.03	E C D
1988-Simpson	1.83	E D
1989-Kaktovik	1.82	E D
1989-Jago	1.79	E
1988-Jago	1.60	E F
1990-Kaktovik	1.57	E F
1990-Jago	1.55	E F
1989-Simpson	1.26	F
1990-Beaufort	0.61	G

TABLE 2.2.– Comparison of daily CPUE (fish/d) observations between fyke net stations for Dolly Varden char in Arctic Refuge coastal waters, 1988-91. Within each year those net stations with the same letter are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons). Net stations with dashed lines were not fished during that year.

	Within year Scheffé groupings			
Station	1988	1989	1990	1991
SC01	A,B	B,C	A	A
SC04	--	C	A	B,C
KL05	A	A,B,C	A	B
KL10	A,B	A,B	A	B,C
JL12	A,B,C	A	A	B,C
JL14	A,B,C	B,C	A	C
PB01	B,C	--	--	--
PB02	C	--	--	--
BL02	--		B	B,C
BL04	--		B	B,C

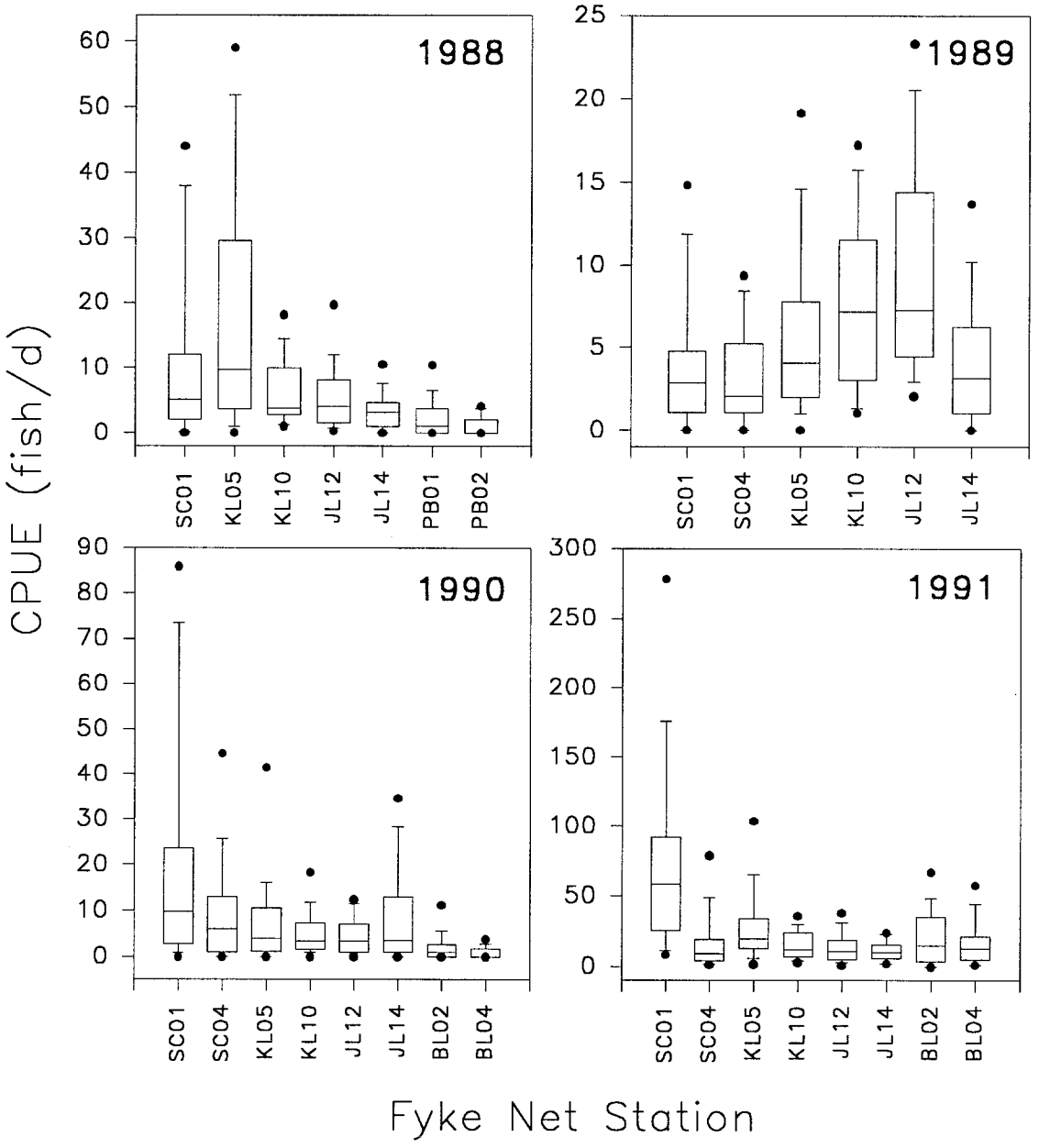

FIGURE 2.1.– Boxplots comparing daily CPUE (fish/d) observations between net stations for Dolly Varden char in Arctic Refuge coastal waters, 1988-91.

TABLE 2.3.– Comparison of daily CPUE (fish/d) observations between sampling areas for Dolly Varden char in Arctic Refuge coastal waters, 1988-91. Within each year those sampling areas with the same letter are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons). Sampling areas with dashed lines were not fished during that year.

	Within year Scheffé groupings			
Sampling area	1988	1989	1990	1991
Simpson Cove	A,B	B	A	A
Kaktovik Lagoon	A	A	A	B
Jago Lagoon	B	A	A	C
Pokok Bay	C	--	--	--
Beaufort Lagoon	--	--	B	B,C

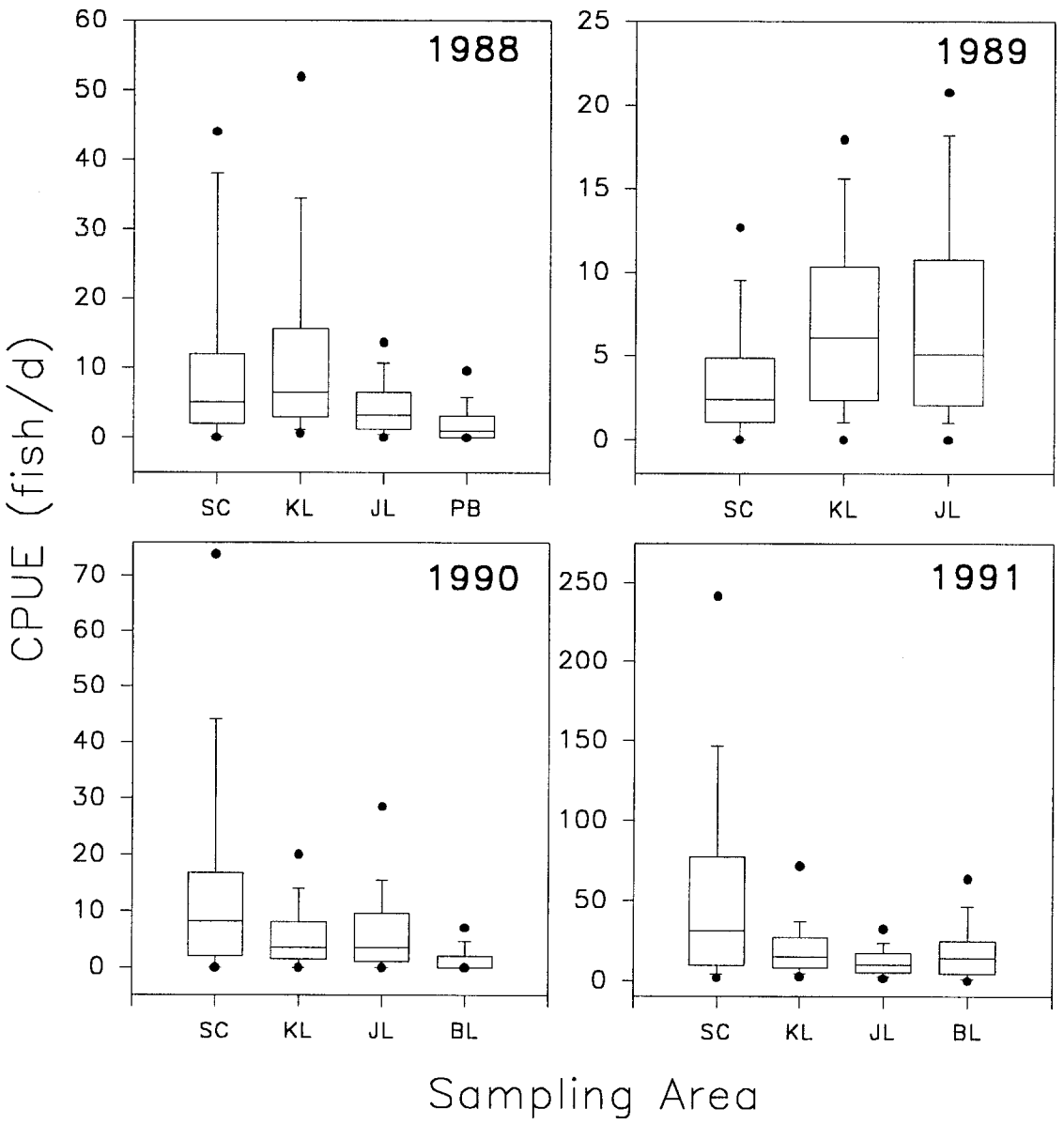

FIGURE 2.2.– Boxplots comparing daily CPUE (fish/d) observations between sampling areas for char in Arctic Refuge coastal waters, 1988-91. SC = Simpson Cove; KL = Kaktovik Lagoon; JL = Jago Lagoon; PB = Pokok Bay; BL = Beaufort Lagoon.

TABLE 2.4.– Comparison of daily CPUE (fish/d) observations between time periods for Dolly Varden char in Simpson Cove. For each net station/sampling area those time periods with the same letter, within each year, are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons). Time period 1 corresponds to the period from the first sampling day to July 31. Time period 2 corresponds to the period from August 1 to August 14. Time period 3 corresponds to the period from August 15 to August 31. Time period 4 corresponds to the period from September 1 to the last sampling day. Locations with dashed lines were not fished during that time period.

	Within year Scheffé groupings			
Time Period	1988	1989	1990	1991
	Net Station - SC01			
1	A	A	A	A
2	A	A	A	B
3	A	A	A	A
4	A	A	B	A,B
	Net Station - SC04			
1	--	A	A	B
2	--	A	A	B
3	--	A	A,B	A
4	--	A	B	--
	Simpson Cove			
1	A	A	A	A,B
2	A	A	A	B
3	A	A	A	A
4	A	A	B	A,B

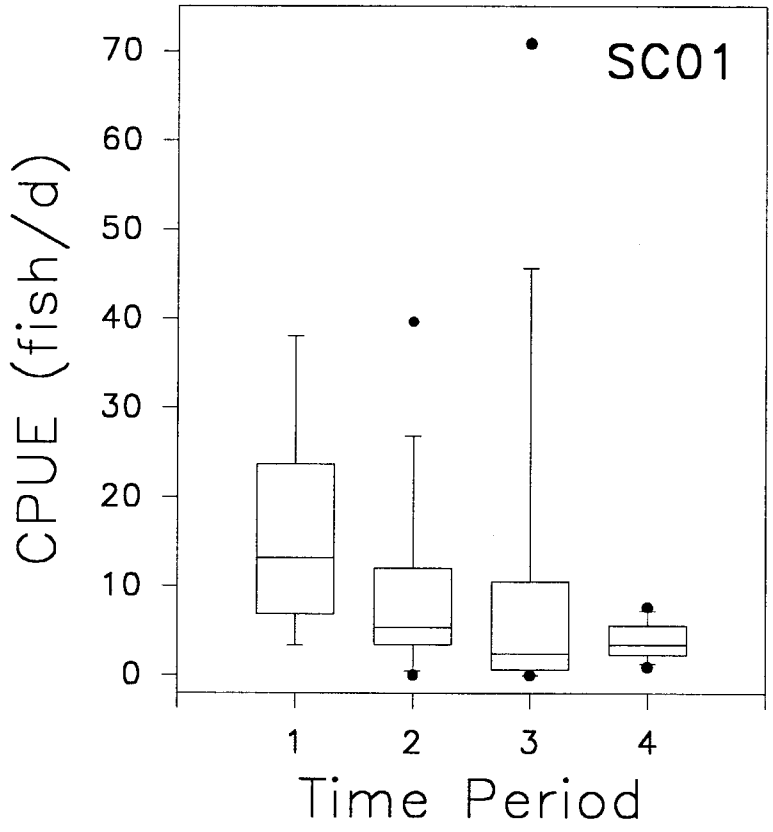

FIGURE 2.3.— Boxplots comparing daily CPUE (fish/day) observations between time periods for char in Simpson Cove in 1988. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 5-31; 4 = September 1 to the last sampling day.

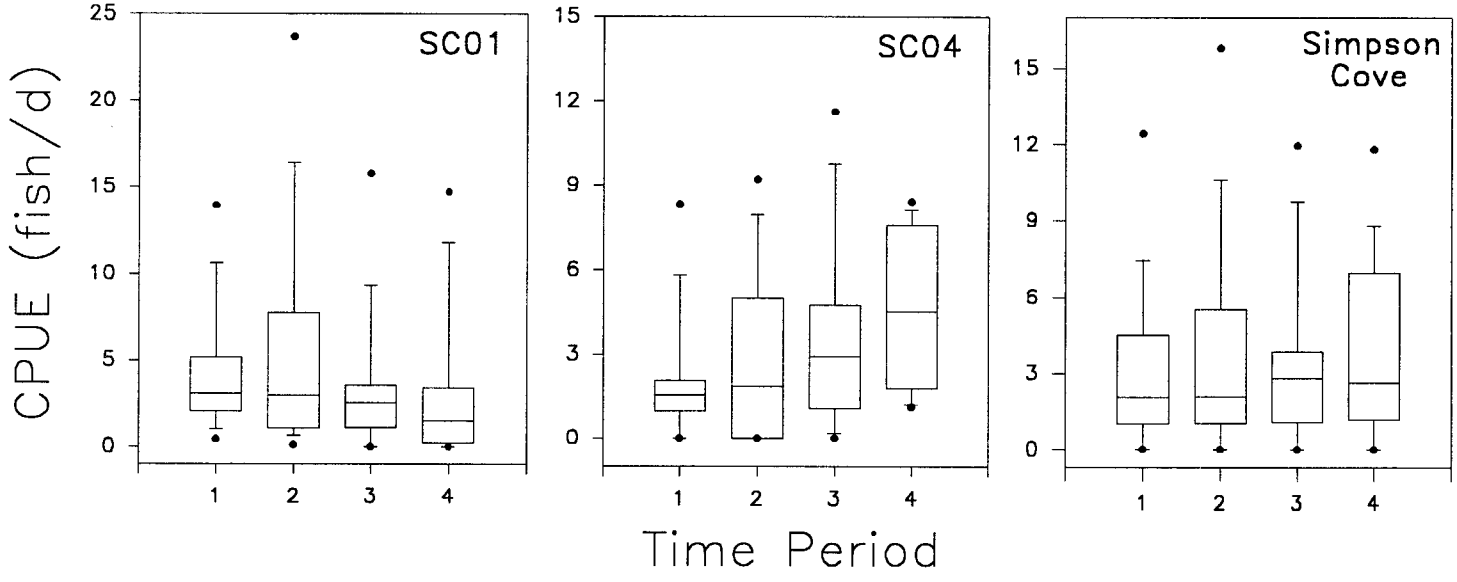

FIGURE 2.4.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Simpson Cove in 1989. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

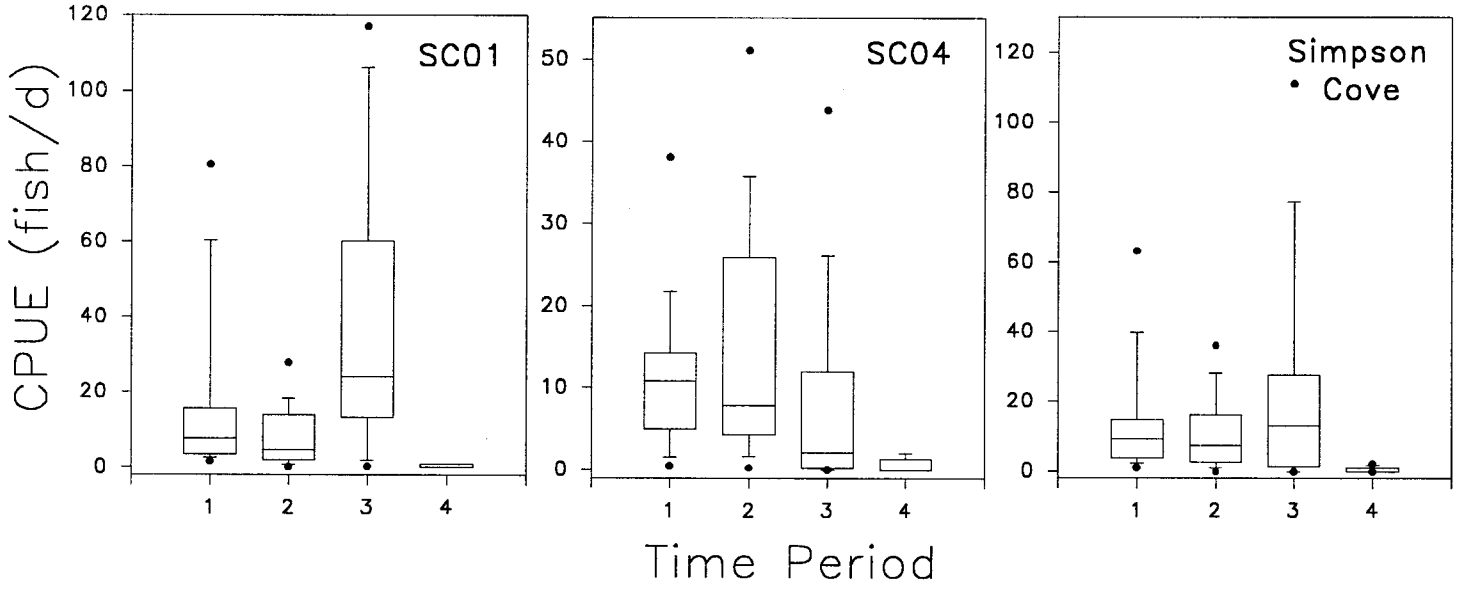

FIGURE 2.5.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Simpson Cove in 1990. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

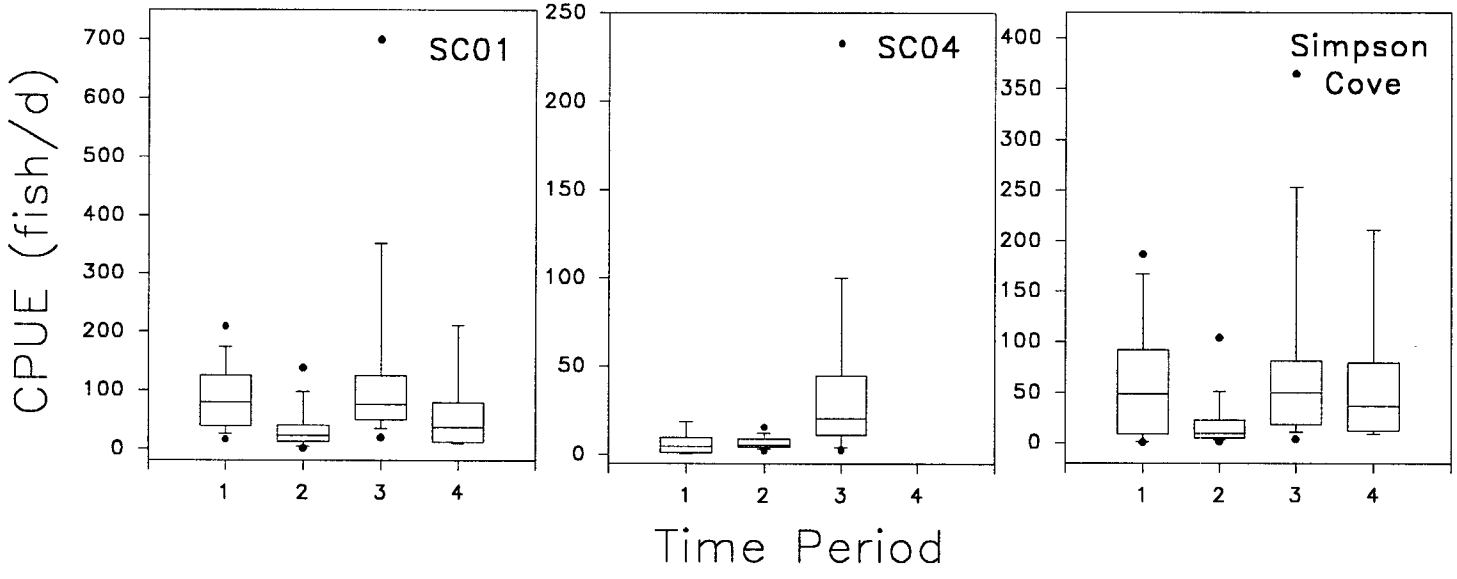

FIGURE 2.6.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Simpson Cove in 1991. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

end of the open-water season. Daily catch rates at net station SC04 increased at the end of August 1991. In the Simpson Cove sampling area daily catch rates were stable during the 1988 and 1989 open-water seasons. During 1990 sampling area daily catch rates declined in early September. In 1991 Simpson Cove daily catch rates differed only between early and late August when they showed an increase. Daily catch rates showed an overall decline at net station KL05 during the 1988, 1989, and 1990 open-water seasons (Table 2.5; Figures 2.7-2.10). During 1991 at net station KL05 daily catch rates only differed between time periods 2 and 4, showing a decrease. In 1988 daily catch rates differed only between time periods 1 and 3, showing a decline. At net station KL10 in 1989 daily catch rates differed only between time periods 1 and 2, indicating a decrease. We documented stable daily catch rates during the 1990 open-water season at net station KL10. Daily catch rates declined at net station KL10 in 1991. In the Kaktovik Lagoon sampling area daily catch rates of Dolly Varden char showed overall declines during the 1988, 1989, 1990, and 1991 open-water seasons.

Daily catch rates at net station JL12 were stable during the 1988 and 1991 open-water seasons (Table 2.6; Figures 2.11-2.14). During the 1989 open-water season daily catch rates showed an overall decline at net station JL12. At net station JL12 in 1991 daily catch rates started low, peaked during August and declined in September. In the 1988 and 1991 open-water seasons daily catch rates of Dolly Varden char at net station JL14 showed overall declines. Late August daily catch rates in 1989 were higher than those in both early August and early September. Net station JL14 daily catch rates in 1990 differed only between time periods 2 and 4. Jago Lagoon sampling area daily catch rates declined during September in each of the years sampled.

During 1988 net stations PB01 and PB02 daily catch rates declined during the open-water season (Table 2.7; Figure 2.15). At net stations BL02 and BL04 in 1990 and 1991, we observed an overall decrease in daily catch rates (Table 2.7; Figures 2.16-2.17). Daily catch rates in the Pokok Bay and Beaufort Lagoon sampling areas declined during the sampling period.

Daily catch rates of Dolly Varden char varied among years within locations (Table 2.8; Figures 2.18.-2.21). Excluding net stations SC04 and JL12, all net stations had higher daily catch rates in 1991. At net stations SC04 between 1990 and 1991, and JL12 between 1989 and 1991, daily catch rates did not differ. The lowest observed daily catch rates occurred at net station SC01 in 1988 and 1989, and at net station SC04 in 1989. For Dolly Varden char the lowest daily catch rates observed at net station KL05 occurred in 1989 and 1990, and at net station KL10 in 1988 and 1990. Net stations BL02 and BL04 had lower daily catch rates during 1990 than during 1991. Daily catch rates did not differ between 1988 and 1990 at net station JL12. At net station JL14 no differences were observed among daily catch rates for 1988, 1989, and 1990.

For all sampling areas, Dolly Varden char daily catch rates during 1991 were higher than in all other years. In Simpson Cove daily catch rates did not differ between 1988 and 1990, and 1989 daily catch rates were the lowest. Dolly Varden char daily catch rates did not differ between 1988 and 1989 or between 1989 and 1990 in Kaktovik Lagoon. Jago Lagoon daily catch rates did

TABLE 2.5.– Comparison of daily CPUE (fish/d) observations between time periods for Dolly Varden char in Kaktovik Lagoon, 1988-91. For each net station/sampling are those time periods with the same letter, within the same year, are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons). Time period 1 corresponds to the period from the first sampling day to July 31. Time period 2 corresponds to the period from August 1 to August 14. Time period 3 corresponds to the period from August 15 to August 31. Time period 4 corresponds to the period from September 1 to the last sampling day.

	Within year Scheffé groupings			
Time Period	1988	1989	1990	1991
	Net Station - KL05			
1	A	A	A	A,B
2	A	B	A,B	A
3	A,B	B	A,B	A,B
4	B	B	B	B
	Net Station - KL10			
1	A	A	A	A
2	A,B	B	A	A,B
3	B	A,B	A	A,B
4	A,B	A,B	A	B
	Kaktovik Lagoon			
1	A	A	A	A
2	A,B	B	A,B	A
3	B	A,B	A,B	A
4	B	B	B	B

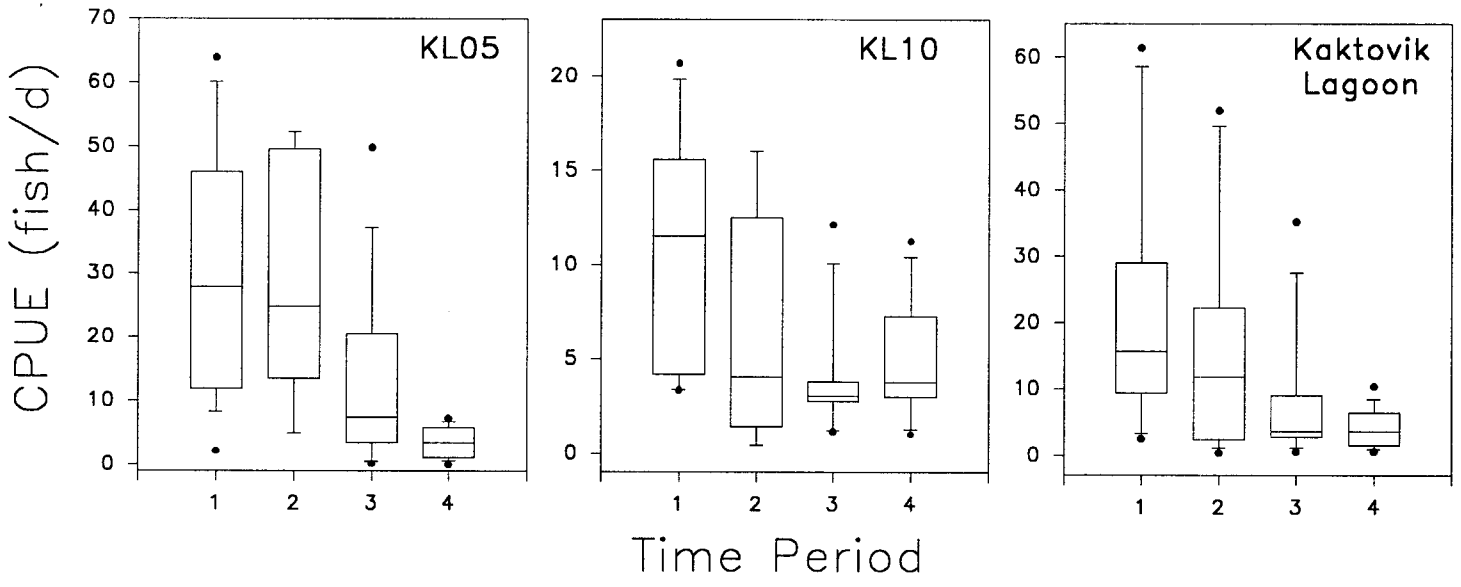

FIGURE 2.7.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Kaktovik Lagoon in 1988. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

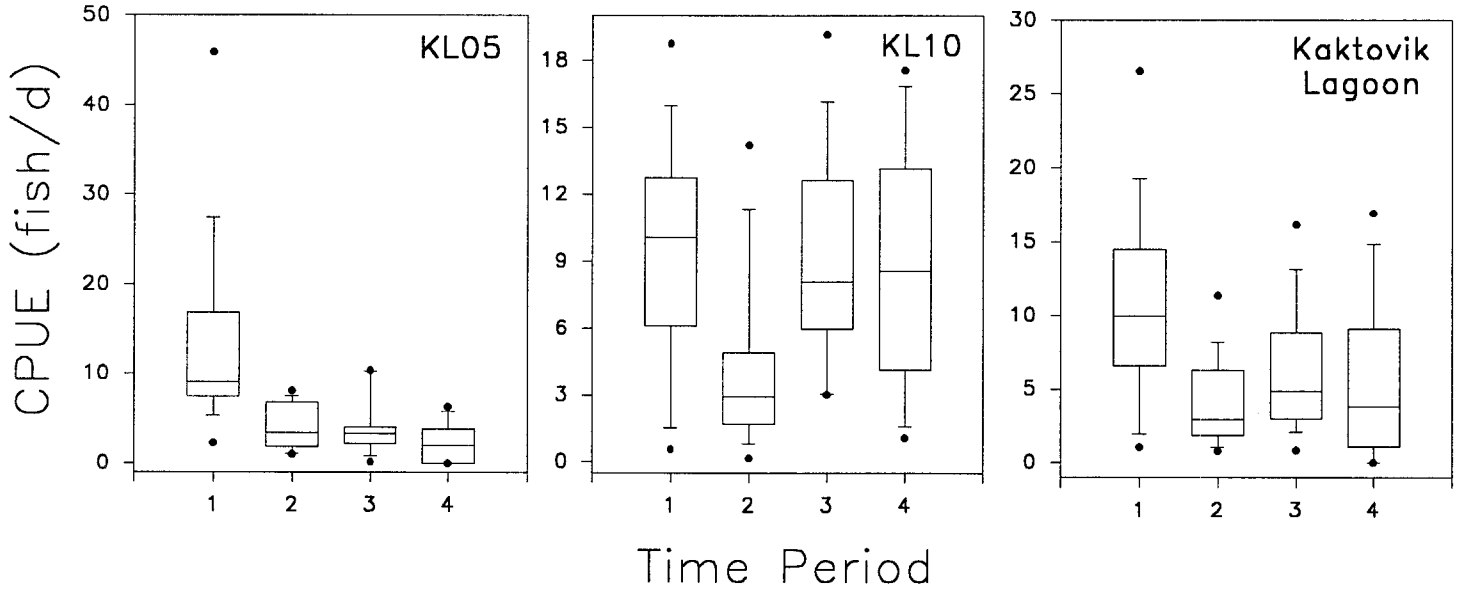

FIGURE 2.8.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Kaktovik Lagoon in 1989. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

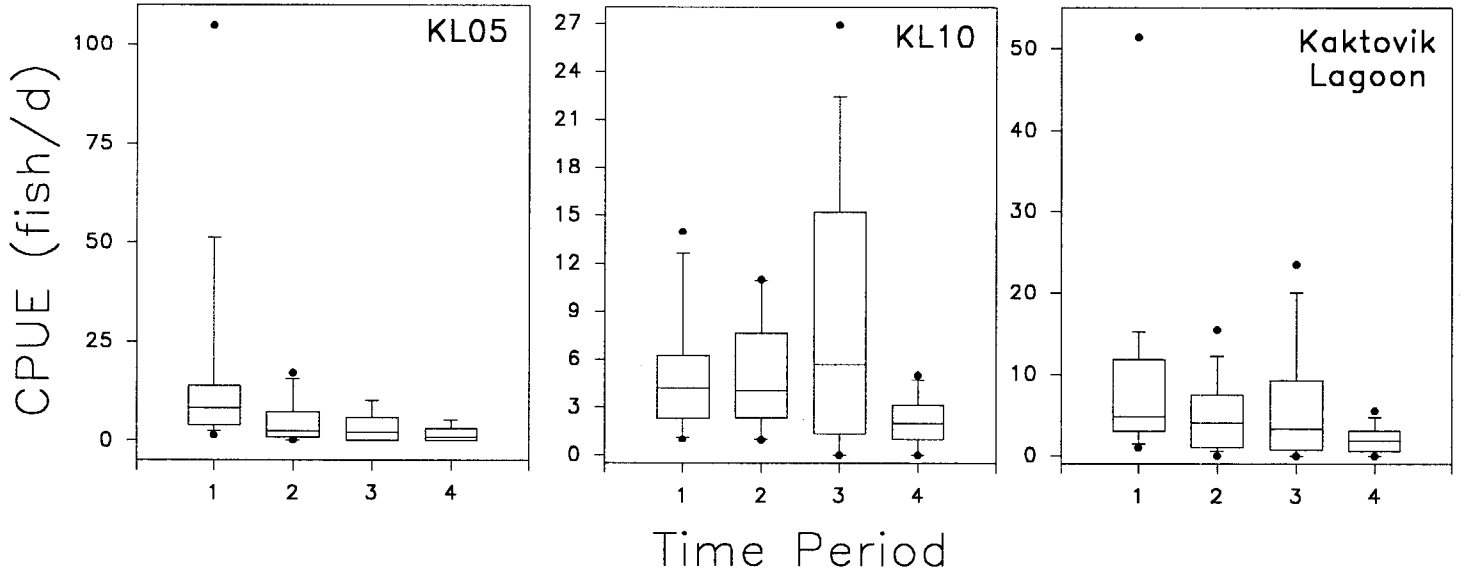

FIGURE 2.9.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Kaktovik Lagoon in 1990. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

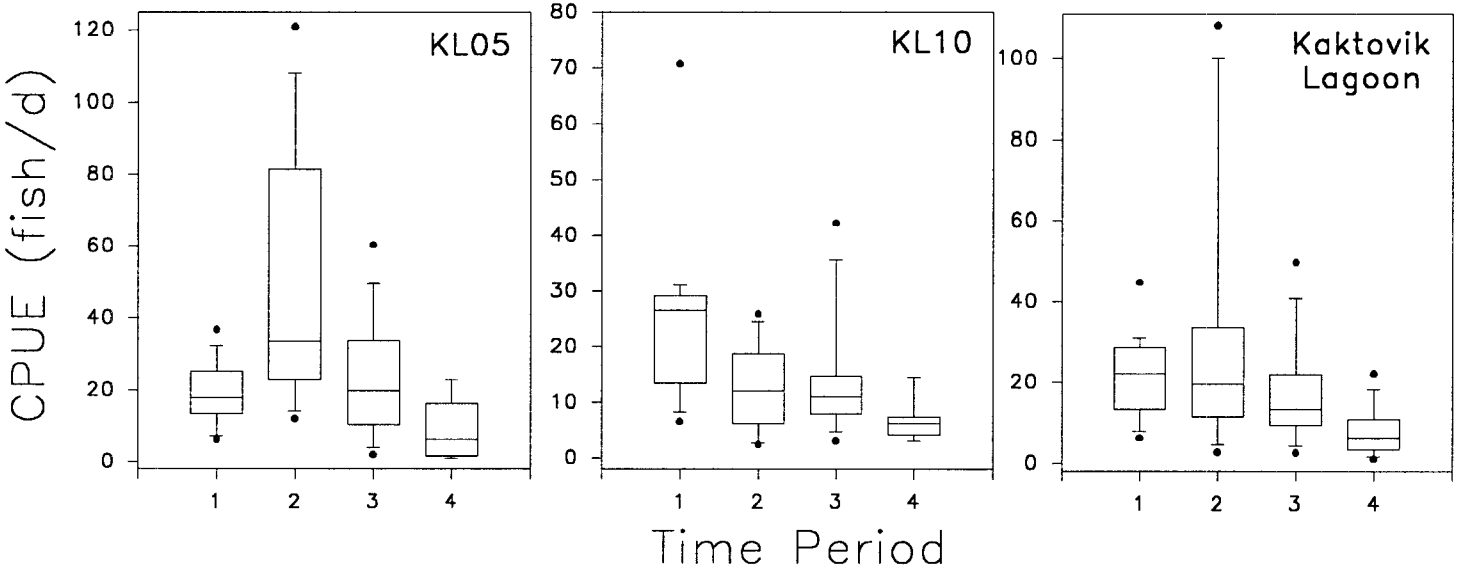

FIGURE 2.10.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Kaktovik Lagoon in 1991. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

TABLE 2.6.– Comparison of daily CPUE (fish/d) observations between time periods for Dolly Varden char in Jago Lagoon, 1988-91. For each net station/sampling area those time periods with the same letter, within the same year, are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons). Time period 1 corresponds to the period from the first sampling day to July 31. Time period 2 corresponds to the period from August 1 to August 14. Time period 3 corresponds to the period from August 15 to August 31. Time period 4 corresponds to the period from September 1 to the last sampling day.

	Within year Scheffé groupings			
Time Period	1988	1989	1990	1991
	Net Station - JL12			
1	A	A	B,C	A
2	A	B	A,B	A
3	A	A,B	A	A
4	A	B	C	A
	Net Station - JL14			
1	A	A,B	A,B	A
2	B	B,C	A	A
3	A,B	A	A,B	A,B
4	B	C	B	B
	Jago Lagoon			
1	A	A	B	A
2	A,B	B	A	A
3	A	A	A	A
4	B	B	B	B

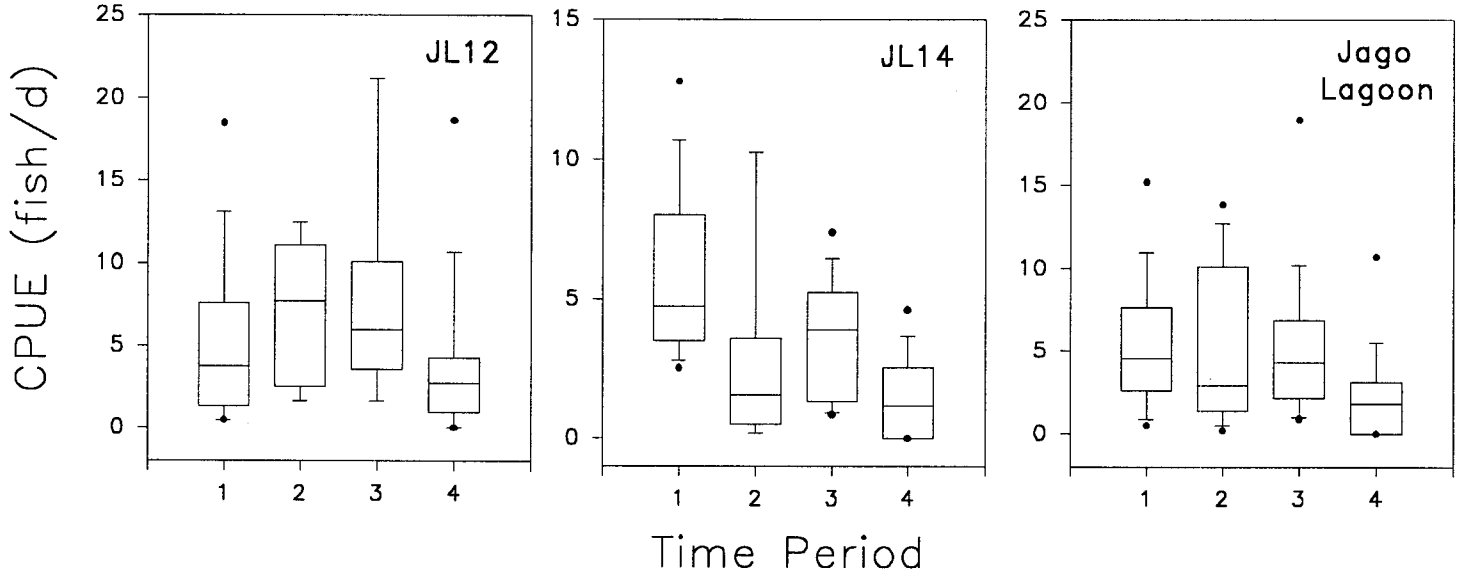

FIGURE 2.11.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Jago Lagoon in 1988. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

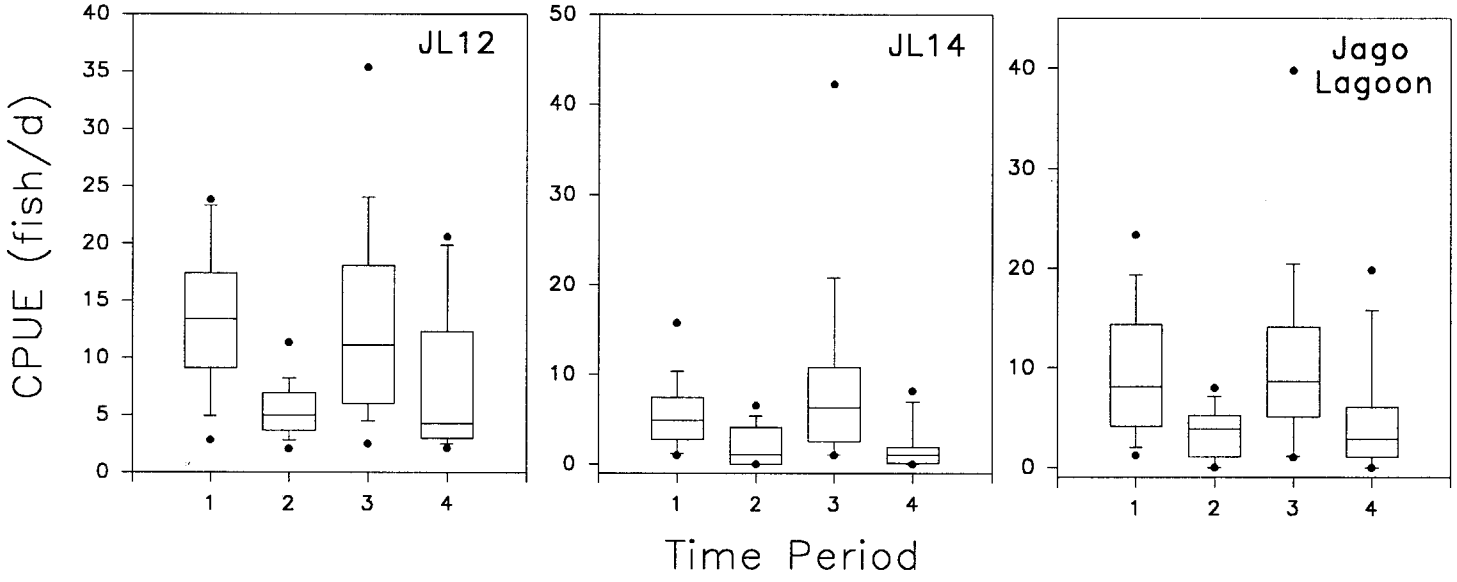

FIGURE 2.12.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Jago Lagoon in 1989. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

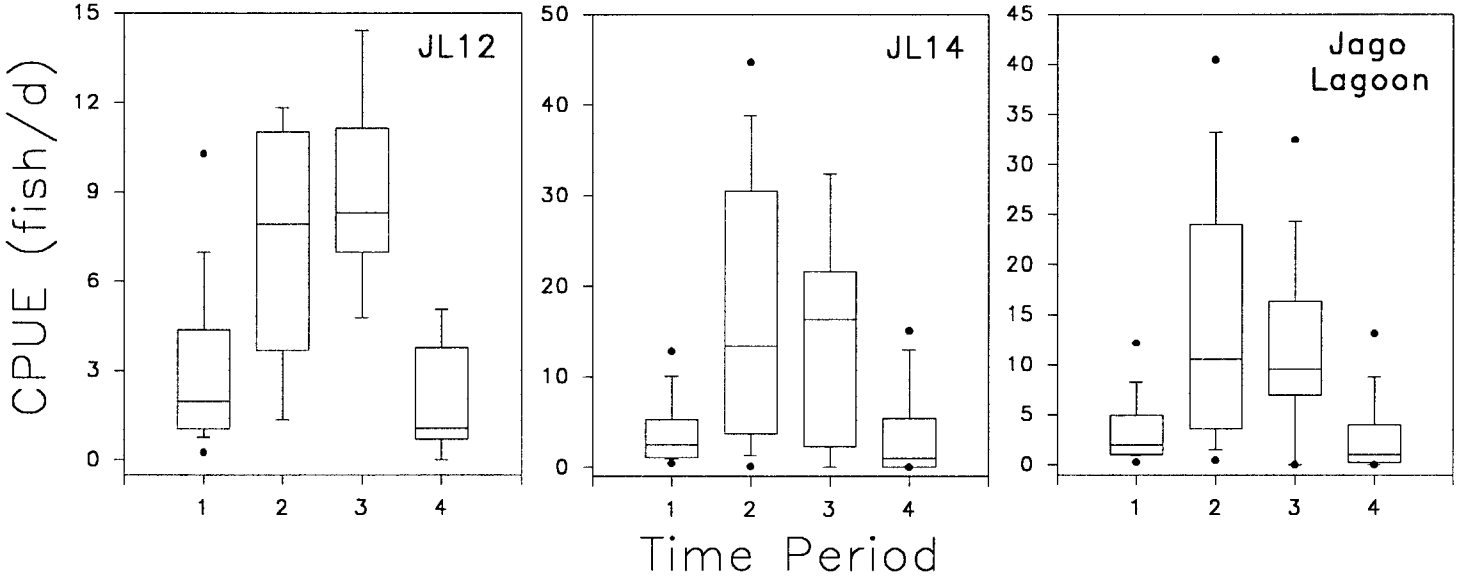

FIGURE 2.13.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Jago Lagoon in 1990. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

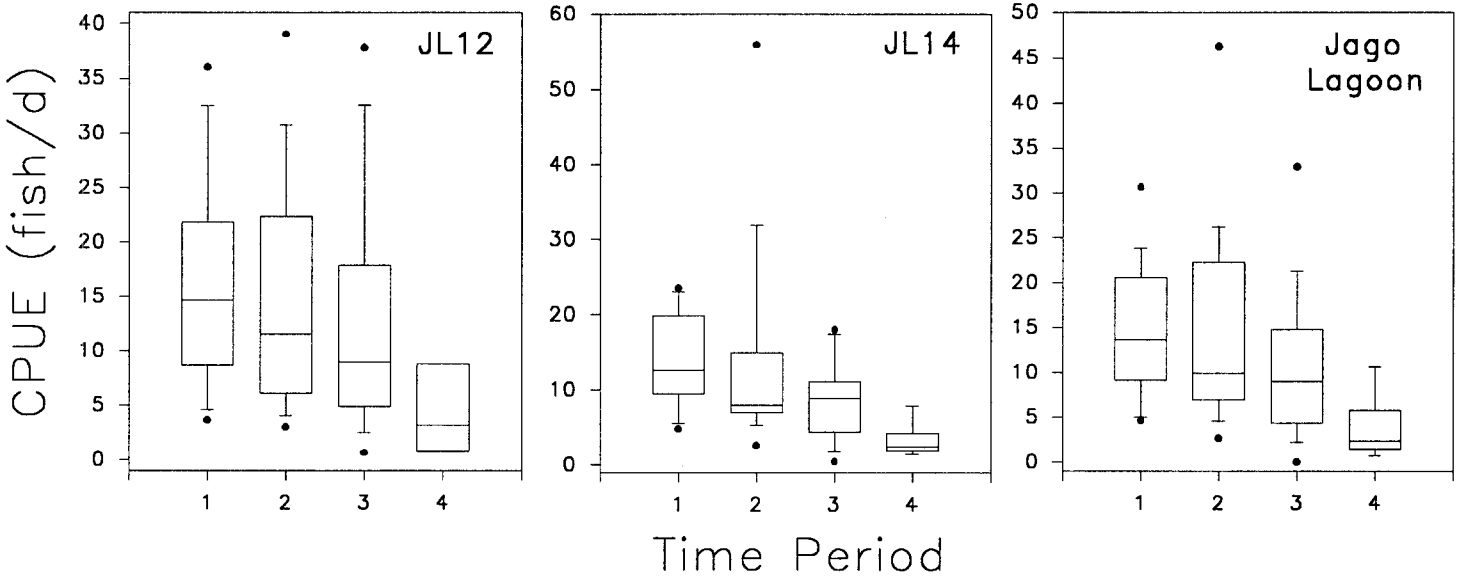

FIGURE 2.14.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Jago Lagoon in 1991. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

TABLE 2.7.– Comparison of daily CPUE (fish/d) observations between time periods for Dolly Varden char in Pokok Bay\Beaufort Lagoon, 1988-91. For each net station/sampling area those time periods with the same letter, within the same year, are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons). Time period 1 corresponds to the period from the first sampling day to July 31. Time period 2 corresponds to the period from August 1 to August 14. Time period 3 corresponds to the period from August 15 to August 31. Time period 4 corresponds to the period from September 1 to the last sampling day. Locations with dashed lines were not fished during that time period.

	Within year Scheffé groupings		
Time Period	1988	1990	1991
	PB01	**BL02**	
1	A	A	A
2	A,B	A,B	A
3	B,C	A,B	A
4	C	B	B
	PB02	**BL04**	
1	--	A	A
2	A	B	A
3	A,B	A,B	A
4	B	B	B
	Pokok Bay	**Beaufort Lagoon**	
1	A	A	A
2	A,B	B	A
3	B,C	A,B	A
4	C	B	B

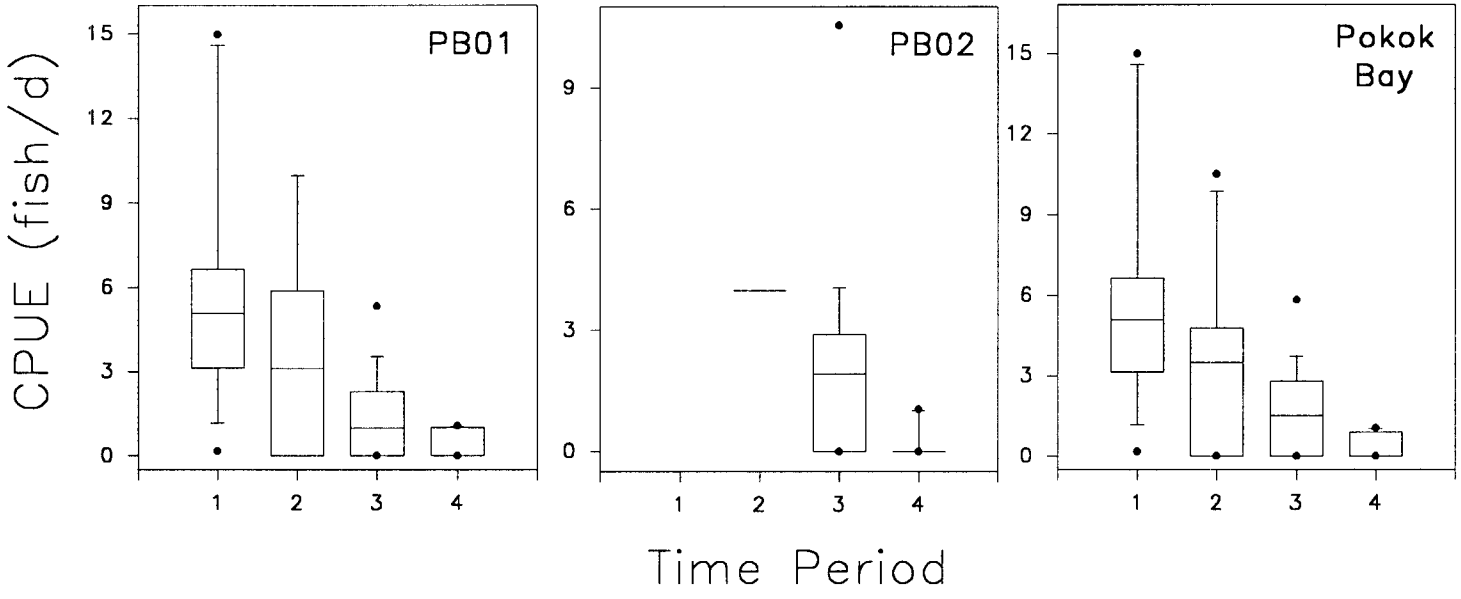

FIGURE 2.15.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Pokok Bay in 1988. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

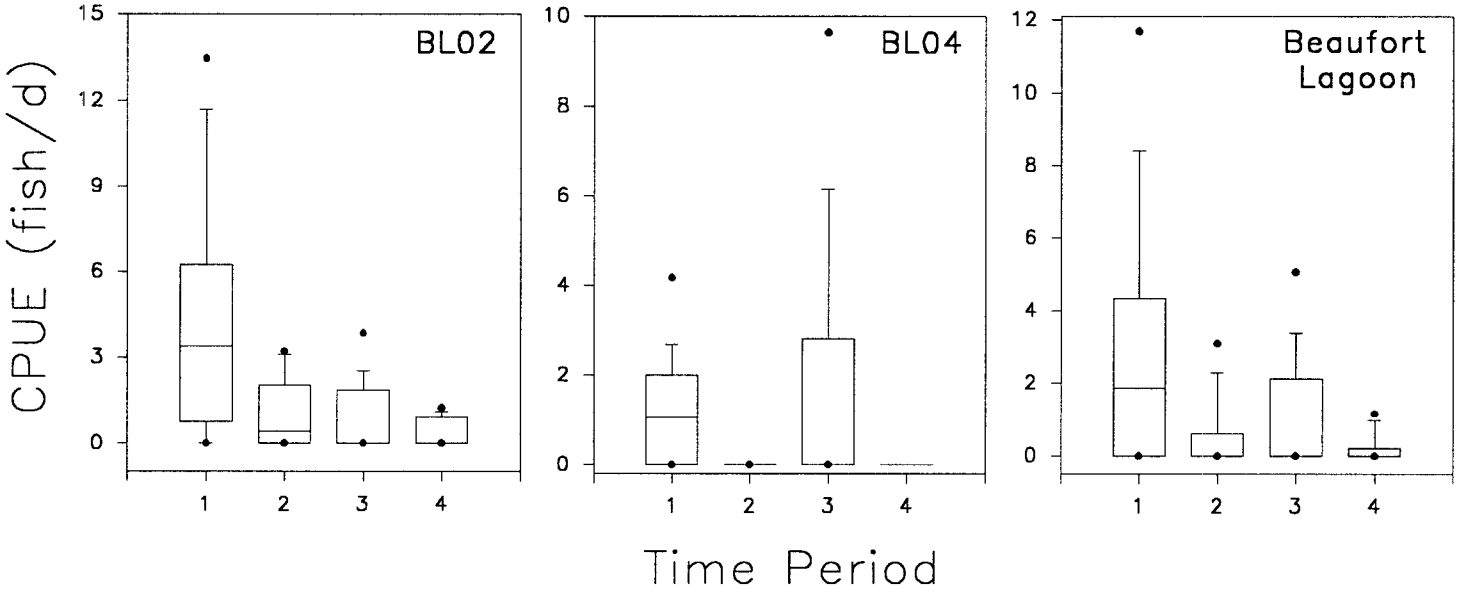

FIGURE 2.16.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Beaufort Lagoon in 1990. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

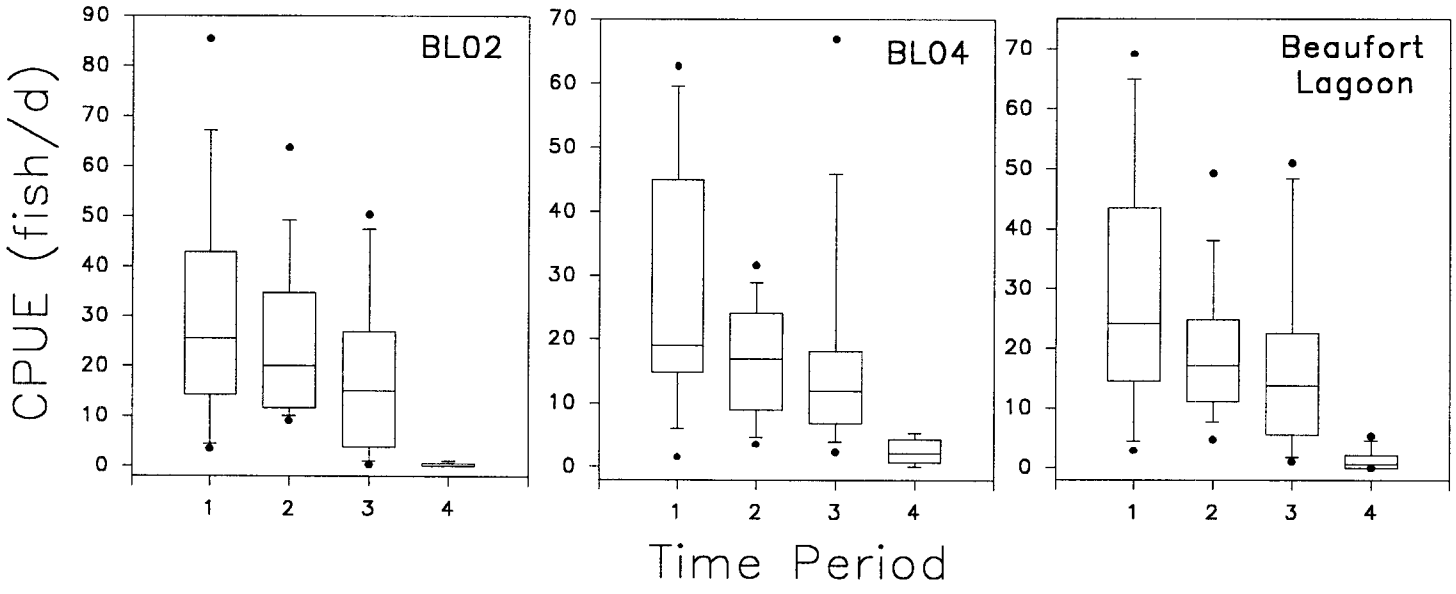

FIGURE 2.17.– Boxplots comparing daily CPUE (fish/d) observations between time periods for char in Beaufort Lagoon in 1991. 1 = the first sampling day to July 31; 2 = August 1 to 14; 3 = August 15 to 31; 4 = September 1 to the last sampling day.

TABLE 2.8.— Comparison of daily CPUE (fish/d) observations between years for Dolly Varden char. For each net station/sampling area those years with the same letter are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons). Locations with dashed lines were not fished during that year.

Year	Within location Scheffé groupings		
	Net Station	Net Station	Sampling Area
	SC01	**SC04**	**Simpson Cove**
1988	B,C	--	B
1989	C	B	C
1990	B	A	B
1991	A	A	A
	KL05	**KL10**	**Kaktovik Lagoon**
1988	B	B,C	B
1989	C	B	B,C
1990	C	C	C
1991	A	A	A
	JL12	**JL14**	**Jago Lagoon**
1988	B	B	C
1989	A	B	B
1990	B	B	B,C
1991	A	A	A
	BL02	**BL04**	**Beaufort Lagoon**
1990	B	B	B
1991	A	A	A

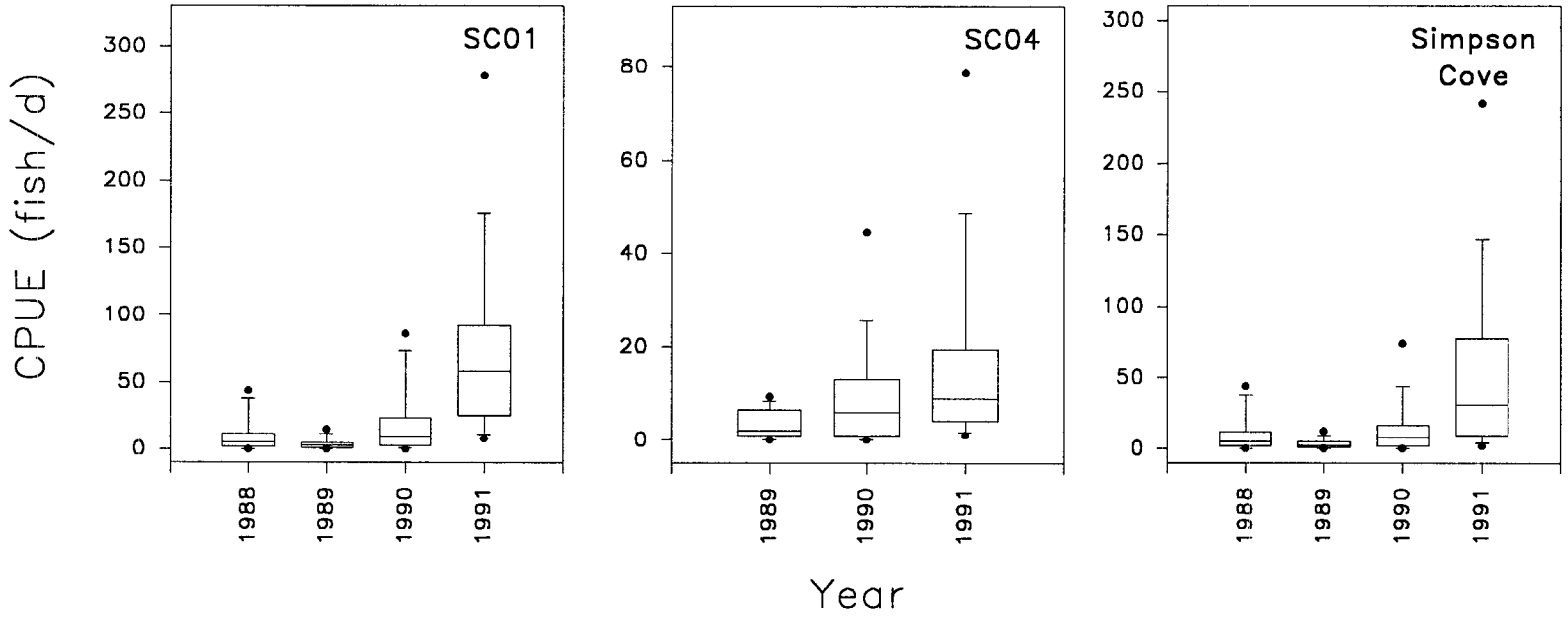

FIGURE 2.18.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Simpson Cove.

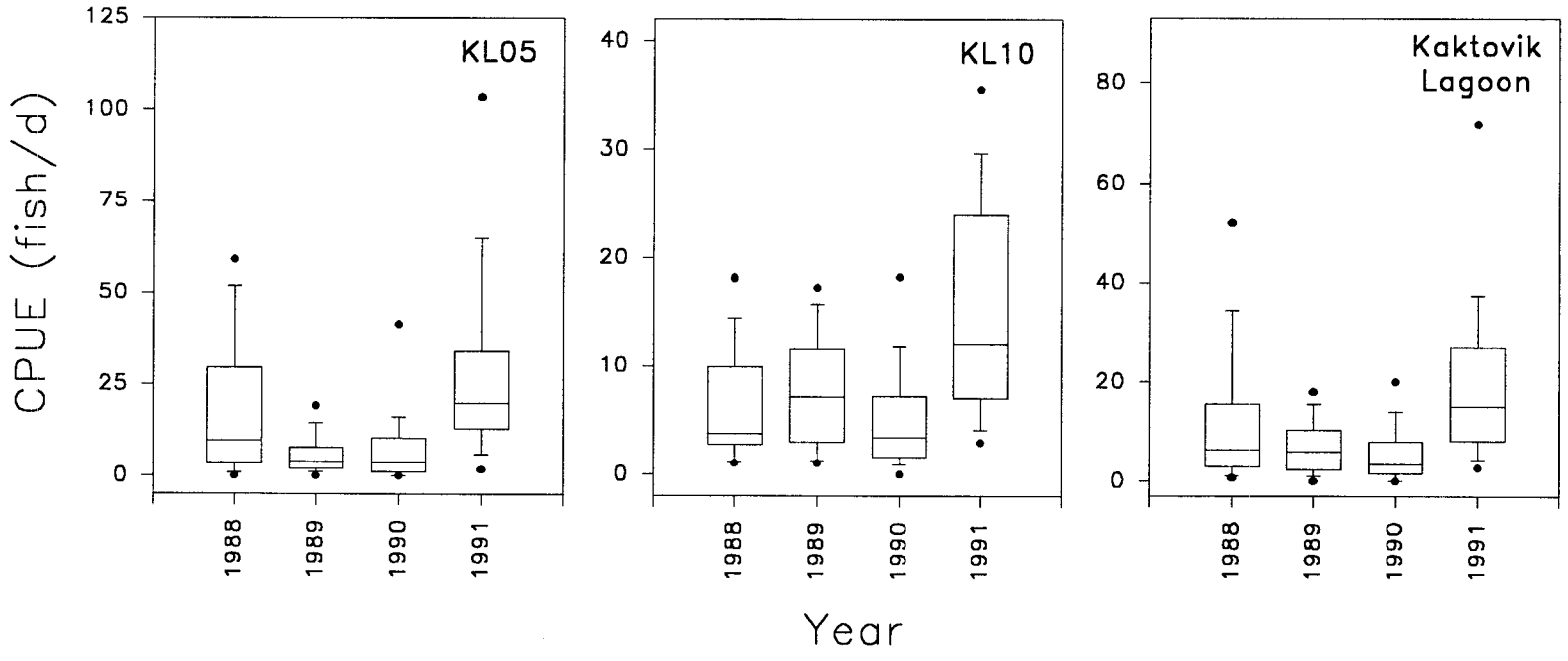

FIGURE 2.19.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Kaktovik Lagoon.

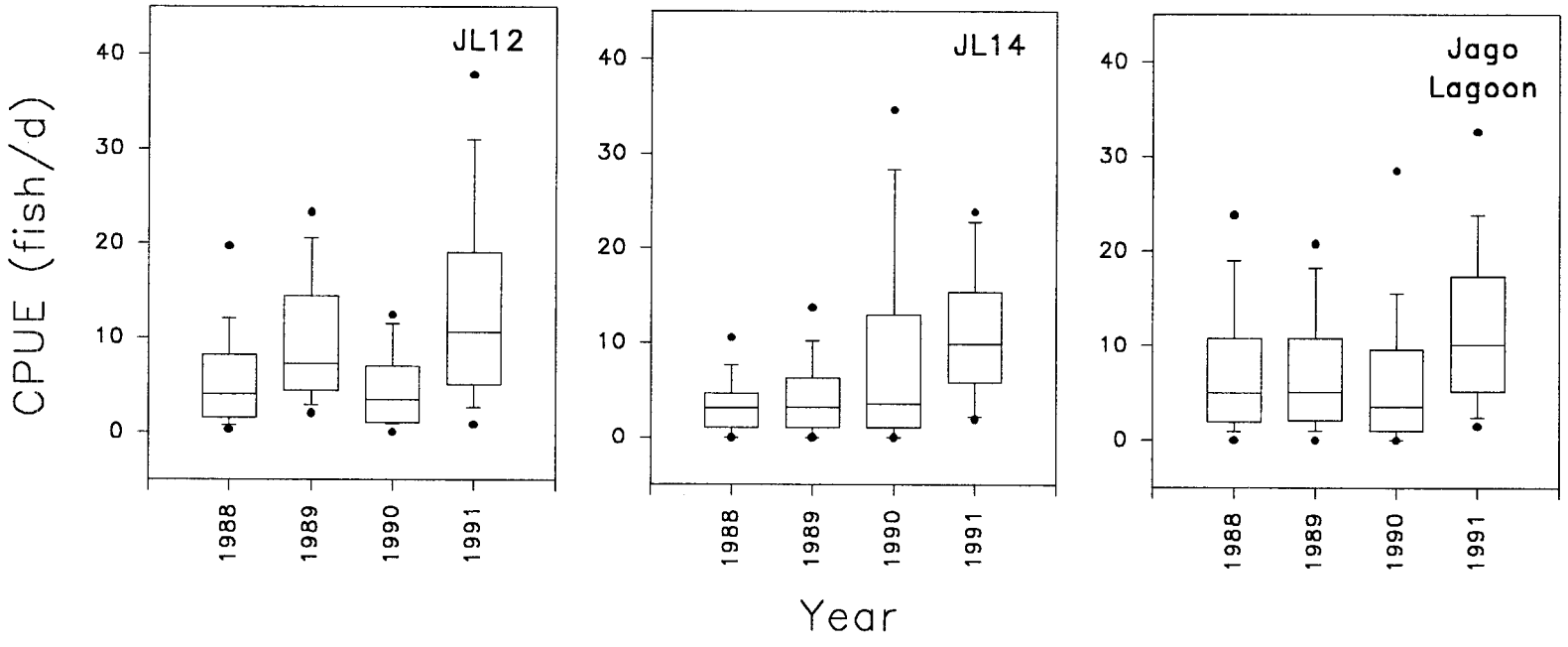

FIGURE 2.20.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Jago Lagoon.

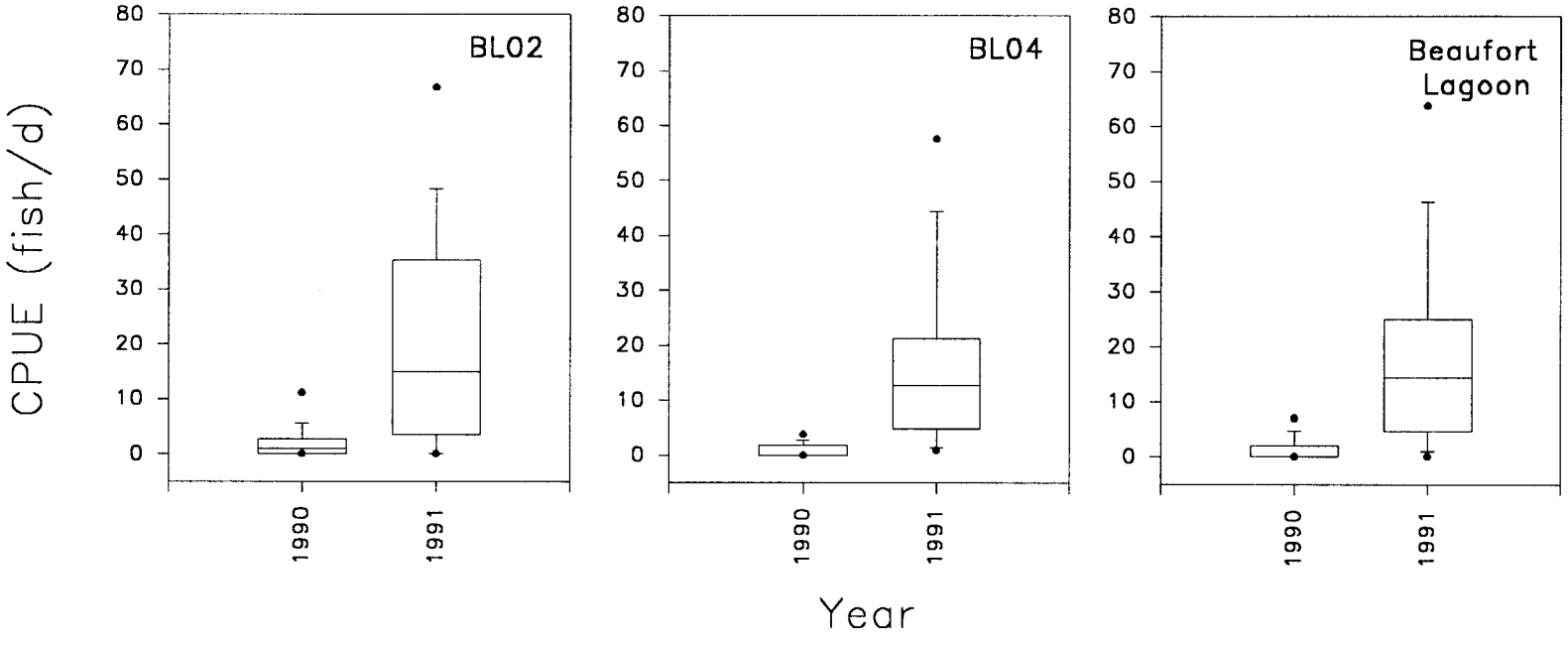

FIGURE 2.21.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Beaufort Lagoon.

For among-year comparisons within time periods, at net station SC01 in time periods 1, 3, and 4, and at net station SC04 in time period 4, 1991 had the highest daily catch rates observed among the years sampled (Table 2.9; Figures 2.22-2.23). At net station SC01 in early August daily catch rates differed only between 1989 and 1991 showing an increase. For net station SC04 daily catch rates in July and early August differed only between 1989 and 1990 showing an increase. At net station SC04 daily catch rates in 1989 were higher than those in 1990. In the Simpson Cove sampling area July 1989 daily catch rates were the lowest among the years sampled. During early August only the daily catch rates for 1989 and 1991 differed showing an increase. In the latter half of August and in September daily catch rates were highest during 1991. Daily catch rates in the latter half of August 1989 and 1990 daily catch rates differed showing an increase. For the Simpson Cove sampling area in September 1988 and 1989 daily catch rates did not differ, but both were higher than those observed during 1990.

At net station KL05, during time periods 1, 3 and 4, and net station KL10 during time periods 2, 3, and 4 daily catch rates did not differ among at least 3 of the 4 years (Table 2.10; Figures 2.24-2.25). During time period 2 at net station KL05 and time period 1 at net station KL10 daily catch rates in 1989 and 1990 did not differ. In the Kaktovik Lagoon sampling area July 1988 and 1991 daily catch rates did not differ; however, July 1991 daily catch rates were higher than those in 1989 and 1990. Daily catch rates during the first half of August in Kaktovik Lagoon did not differ between 1988 and 1991; whereas, daily catch rates in 1991 were higher than those observed for 1989 and 1990. For the Kaktovik Lagoon sampling area in the latter part of August daily catch rates did not differ among 1988, 1989, and 1990, and were highest during 1991. During time period 4 in Kaktovik Lagoon daily catch rates differed only between 1990 and 1991 indicating an increase.

During time period 1 at net station JL12 daily catch rates did not differ between 1988 and 1990 or between 1989 and 1991 (Table 2.11; Figures 2.26-2.27). July daily catch rates for 1989 and 1991 were higher than those for 1988 and 1990. At net station JL12 we observed no differences in daily catch rates among years during time periods 2, 3 or 4. Daily catch rates at net station JL14 in July were highest in 1991 and did not differ among 1988, 1989, and 1990. During the first half of August daily catch rates were higher in the second two years of the sampling. After August 15 at net station JL14 daily catch rates did not differ among years. In the Jago Lagoon sampling area July daily catch rates showed an overall increase during the four years of study. Daily catch rates in time period 2 were higher in 1990 and 1991 than those observed in 1988 and 1989. After August 15 daily catch rates in the Jago Lagoon sampling area did not differ between years.

July and August daily catch rates at net station BL02 were higher in 1990 than in 1991 (Table 2.12; Figures 2.28-2.29). In September net station BL02 daily catch rates did not differ between 1990 and 1991. During all time periods at net station BL04 and in the Beaufort Lagoon sampling area daily catch rates were higher in 1991 than in 1990. Daily catch rates of Dolly Varden char varied between years within locations (Table 2.8; Figures 2.18-2.21). Excluding net station SC04 and JL12, all net stations highest

TABLE 2.9.– Comparison of daily CPUE (fish/d) observations between years for Dolly Varden char in Simpson Cove. For each net station/sampling area those years with the same letter, within the time period, are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons). Locations with dashed lines were not sampled during that year.

	Within location Scheffé groupings		
Year	SC01	SC04	Simpson Cove
Time Period 1 - first day to July 31			
1988	B	--	A
1989	C	B	B
1990	B	A	A
1991	A	A,B	A
Time Period 2 - August 1 to August 14			
1988	A,B	--	A,B
1989	B	B	B
1990	A,B	A	A,B
1991	A	A,B	A
Time Period 3 - August 15 to August 31			
1988	C	--	B,C
1989	C	B	C
1990	B	B	B
1991	A	A	A
Time Period 4 - September 1 to last day			
1988	B	--	B
1989	B,C	A	B
1990	C	B	C
1991	A	--	A

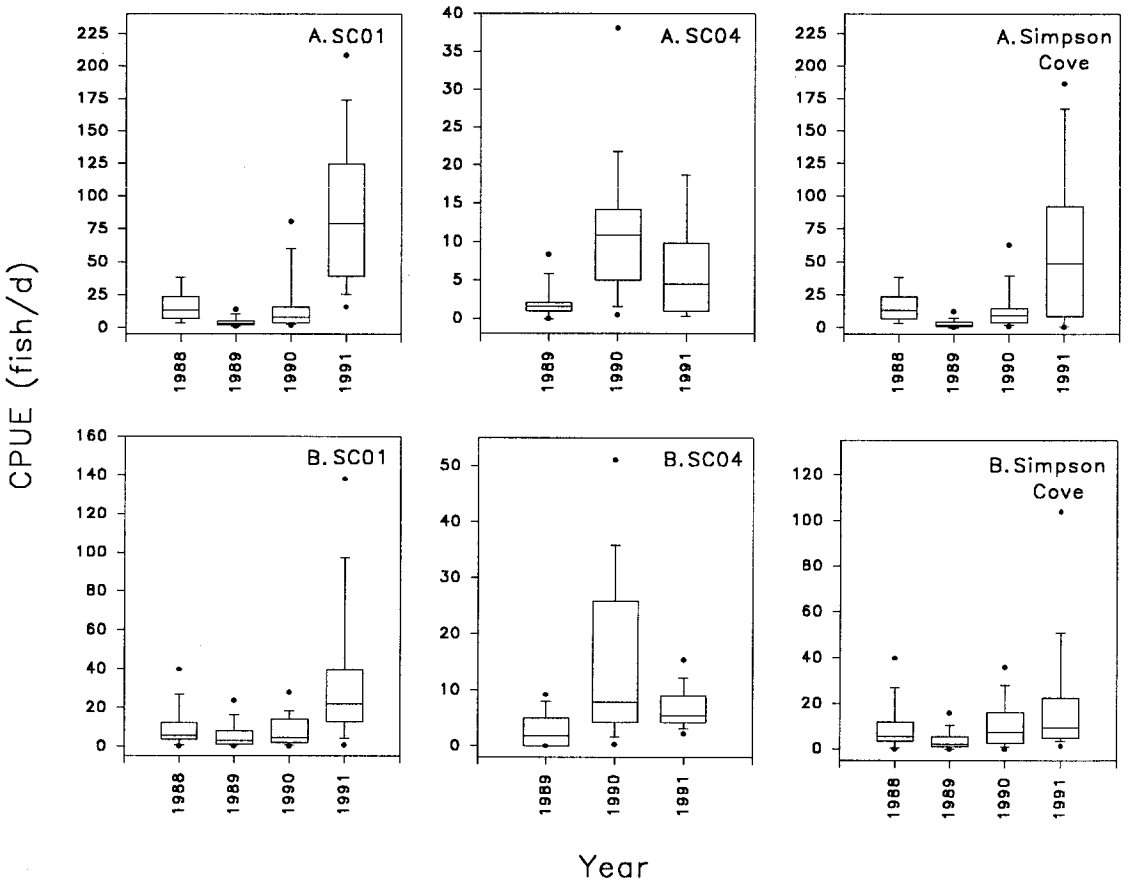

FIGURE 2.22.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Simpson Cove. A = time period 1, the first sampling day to July 31. B = time period 2, August 1 to August 14.

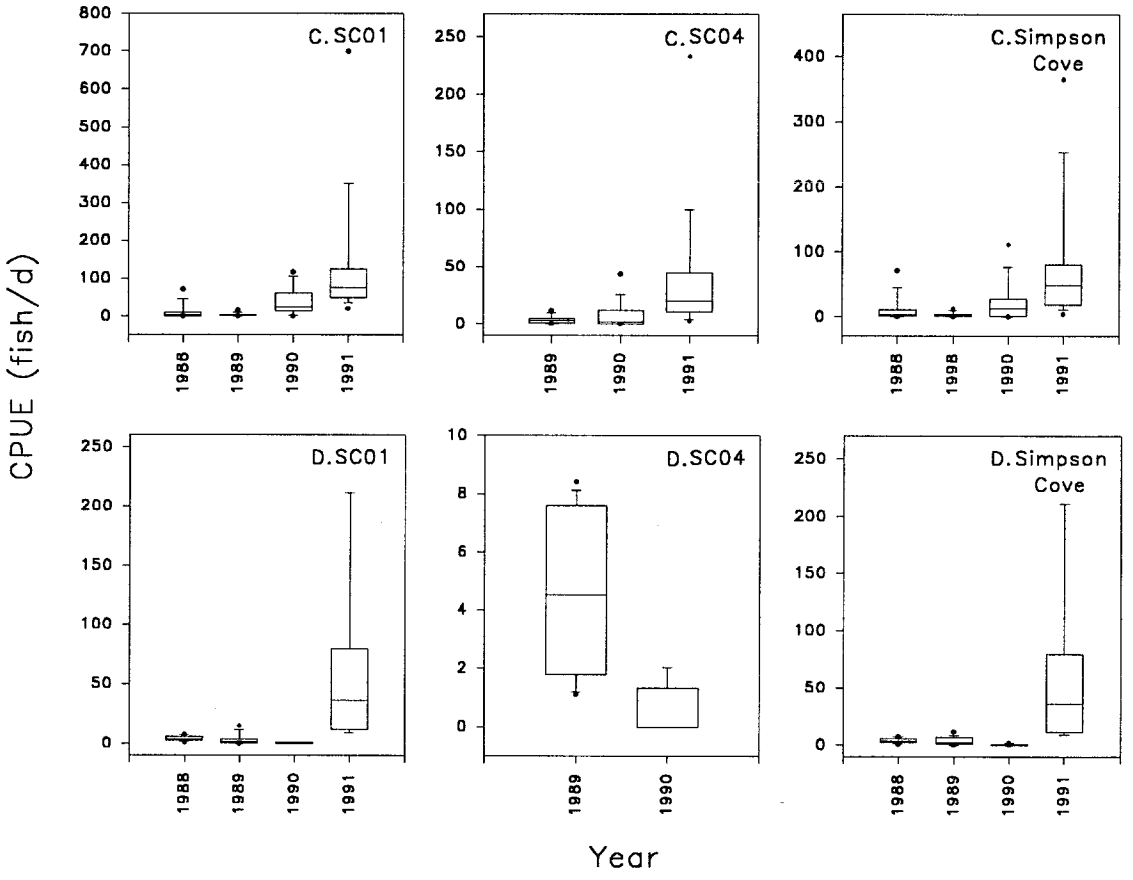

FIGURE 2.23.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Simpson Cove. C = time period 3, August 15 to August 31. D = time period 4, September 1 to the last sampling day.

TABLE 2.10.– Comparison of daily CPUE (fish/d) observations between years for Dolly Varden char in Kaktovik Lagoon. For each net station/sampling area those years with the same letter, within the time period, are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons).

	Within location Scheffé groupings		
Year	KL05	KL10	Kaktovik Lagoon
Time Period 1 - first day to July 31			
1988	A	B	A,B
1989	A,B	B,C	B,C
1990	B	C	C
1991	A,B	A	A
Time Period 2 - August 1 to August 14			
1988	A	A,B	A,B
1989	B	B	C
1990	B	A,B	B,C
1991	A	A	A
Time Period 3 - August 15 to August 31			
1988	A,B	B	B
1989	B	A,B	B
1990	B	A,B	B
1991	A	A	A
Time Period 4 - September 1 to last day			
1988	A	A,B	A,B
1989	A	A	A,B
1990	A	B	B
1991	A	A	A

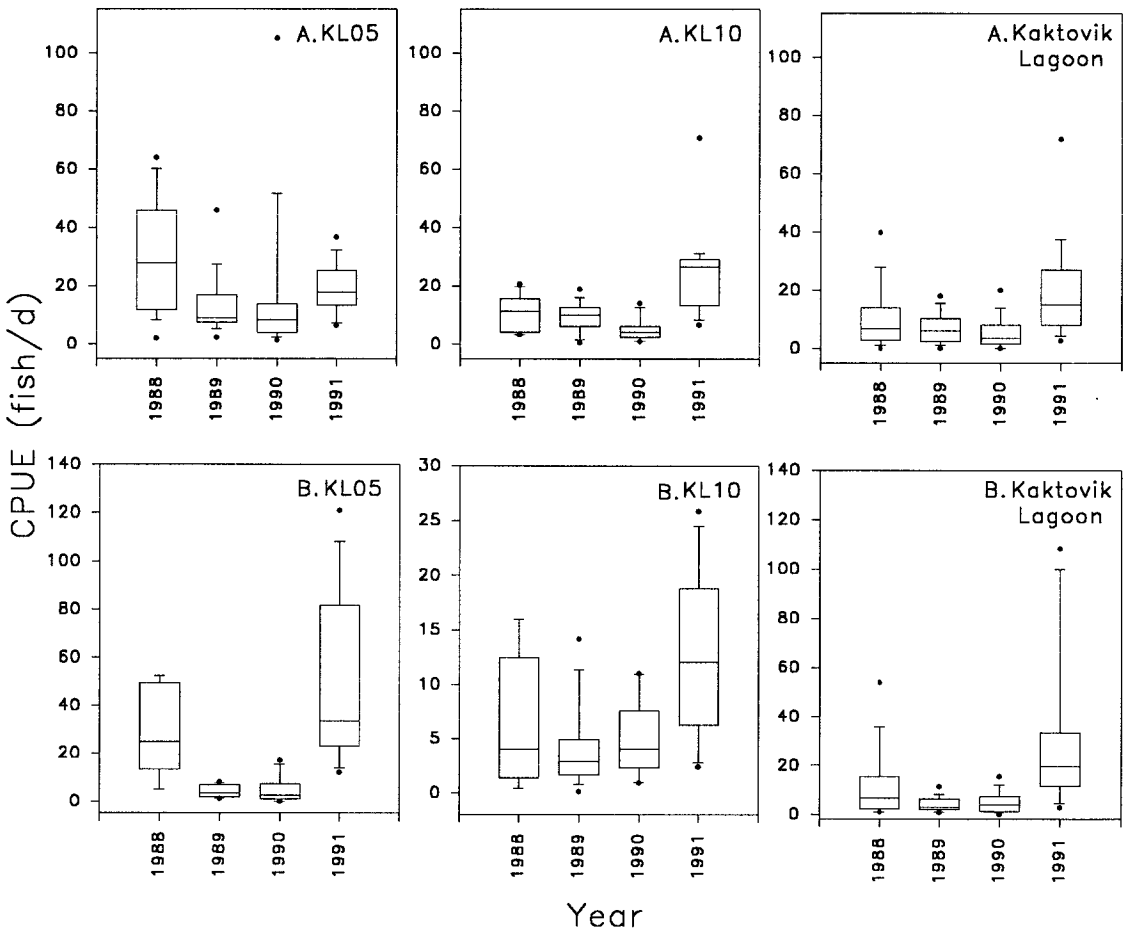

FIGURE 2.24.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Kaktovik Lagoon. A = time period 1, the first sampling day to July 31. B = time period 2, August 1 to August 14.

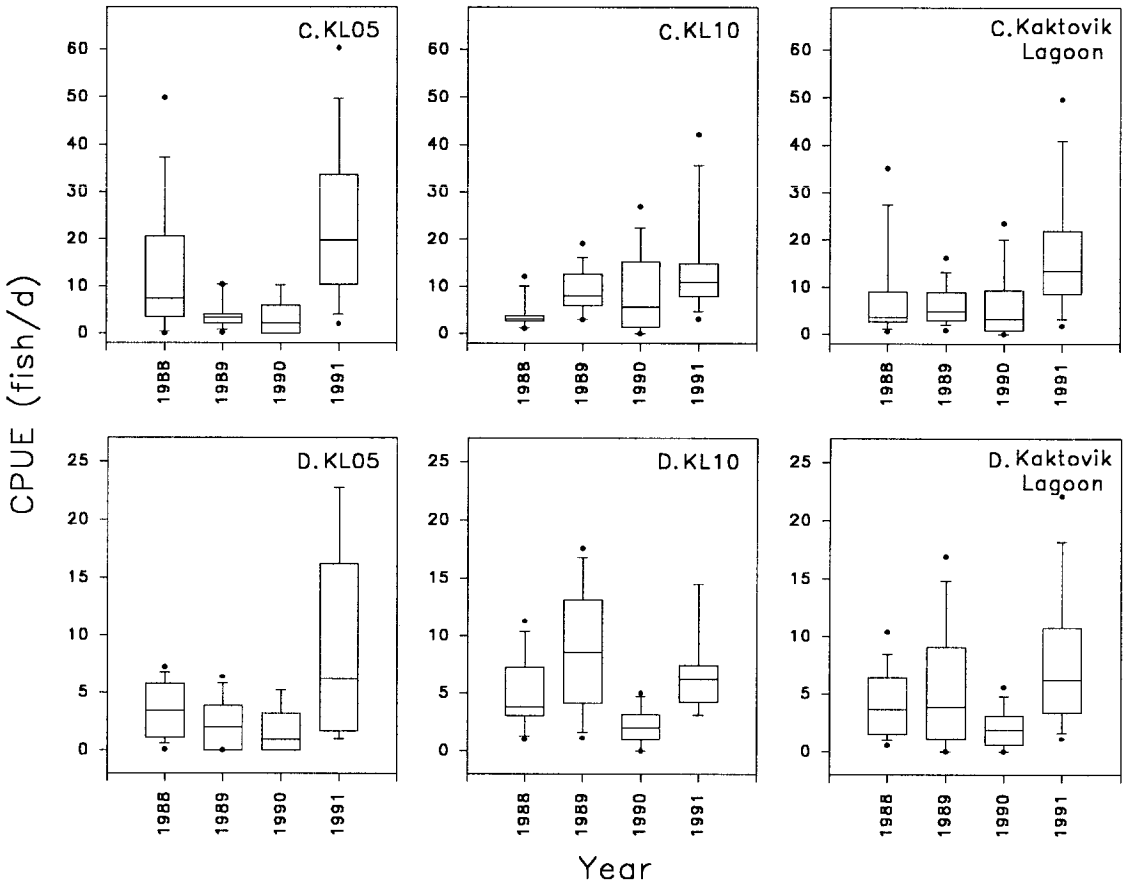

FIGURE 2.25.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Kaktovik Lagoon. C = time period 3, August 15 to August 31. D = time period 4, September 1 to the last sampling day.

TABLE 2.11.– Comparison of daily CPUE (fish/d) observations between years for Dolly Varden char in Jago Lagoon. For each net station/sampling area those years with the same letter, within the time period, are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons).

	Within location Scheffé groupings		
Year	JL12	JL14	Jago Lagoon
Time Period 1 - first day to July 31			
1988	B	B	C
1989	A	B	B
1990	B	B	B,C
1991	A	A	A
Time Period 2 - August 1 to August 14			
1988	A	B	B
1989	A	B	B
1990	A	A	A
1991	A	A	A
Time Period 3 - August 15 to August 31			
1988	A	A	A
1989	A	A	A
1990	A	A	A
1991	A	A	A
Time Period 4 - September 1 to last day			
1988	A	A	A
1989	A	A	A
1990	A	A	A
1991	A	A	A

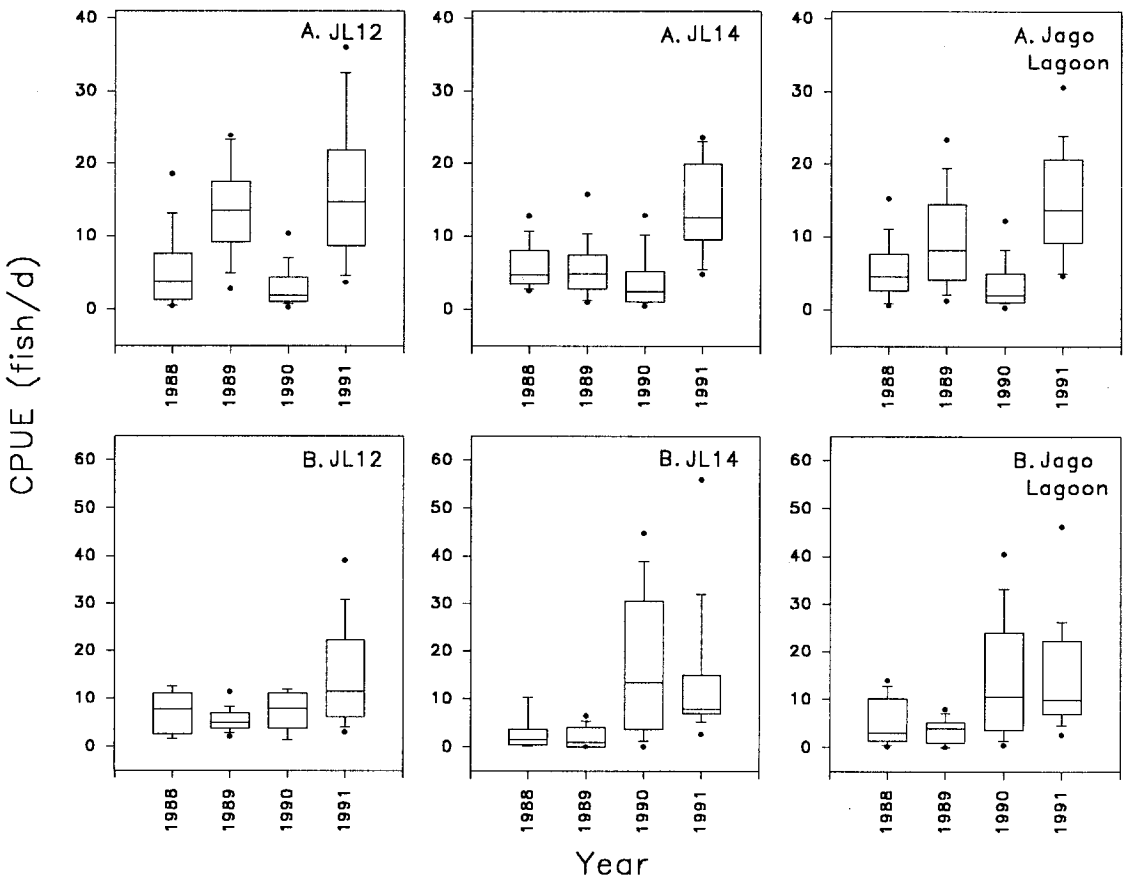

FIGURE 2.26.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Jago Lagoon. A = time period 1, the first sampling day to July 31. B = time period 2, August 1 to August 14.

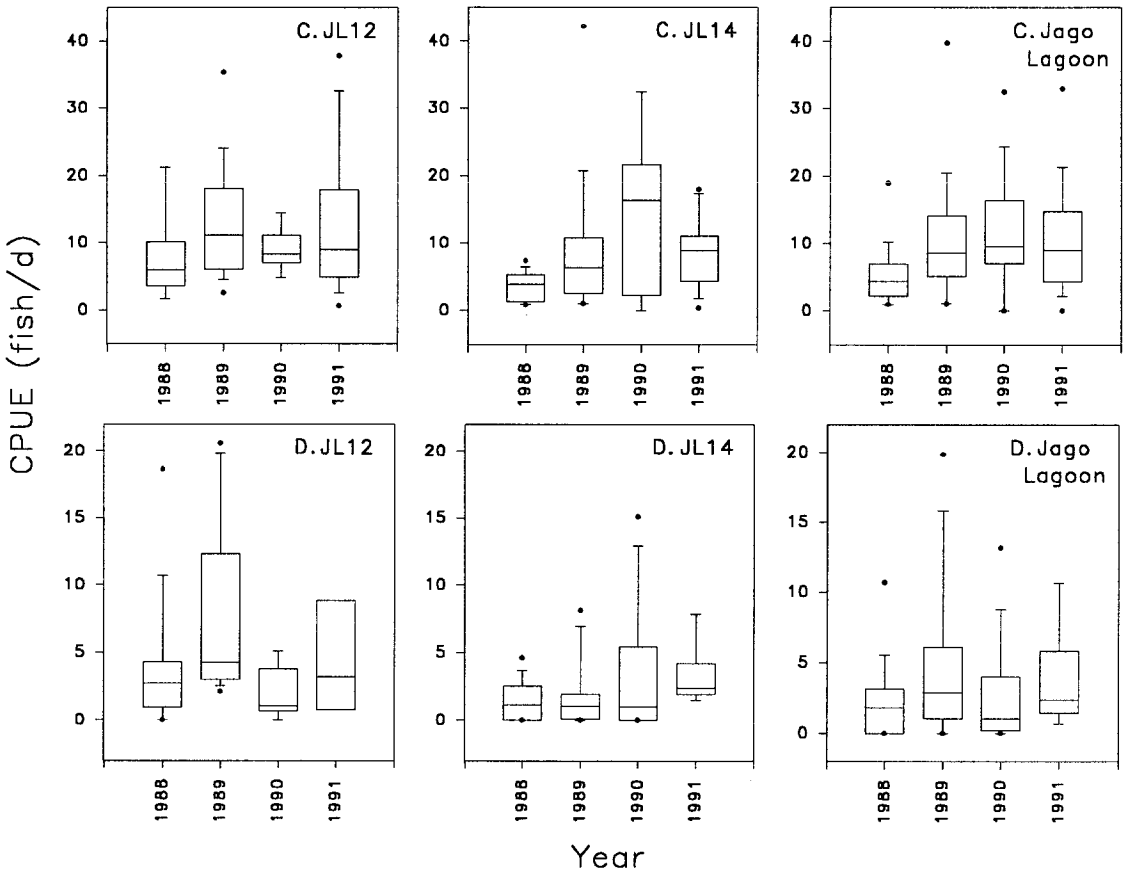

FIGURE 2.27.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Jago Lagoon. C = time period 3, August 15 to August 31. D = time period 4, September 1 to the last sampling day.

TABLE 2.12.– Comparison of daily CPUE (fish/d) observations between years for Dolly Varden char in Beaufort Lagoon. For each net station/sampling area those years with the same letter, within the time period, are not significantly different (Kruskal-Wallis test with Scheffé multiple comparisons).

	Within location Scheffé groupings		
Year	BL02	BL04	Beaufort Lagoon
Time Period 1 - first day to July 31			
1990	B	B	B
1991	A	A	A
Time Period 2 - August 1 to August 14			
1990	B	B	B
1991	A	A	A
Time Period 3 - August 15 to August 31			
1990	B	B	B
1991	A	A	A
Time Period 4 - September 1 to last day			
1990	A	B	B
1991	A	A	A

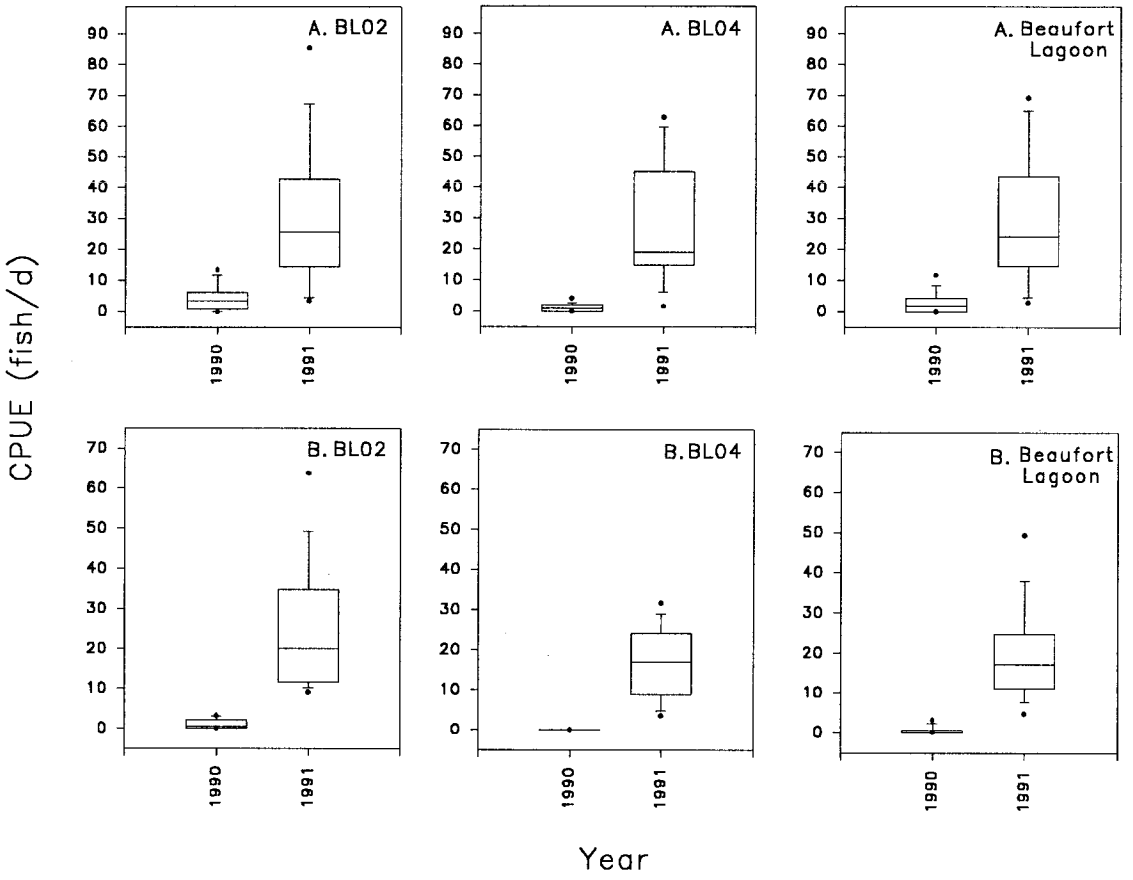

FIGURE 2.28.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Beaufort Lagoon. A = time period 1, the first sampling day to July 31. B = time period 2, August 1 to August 14.

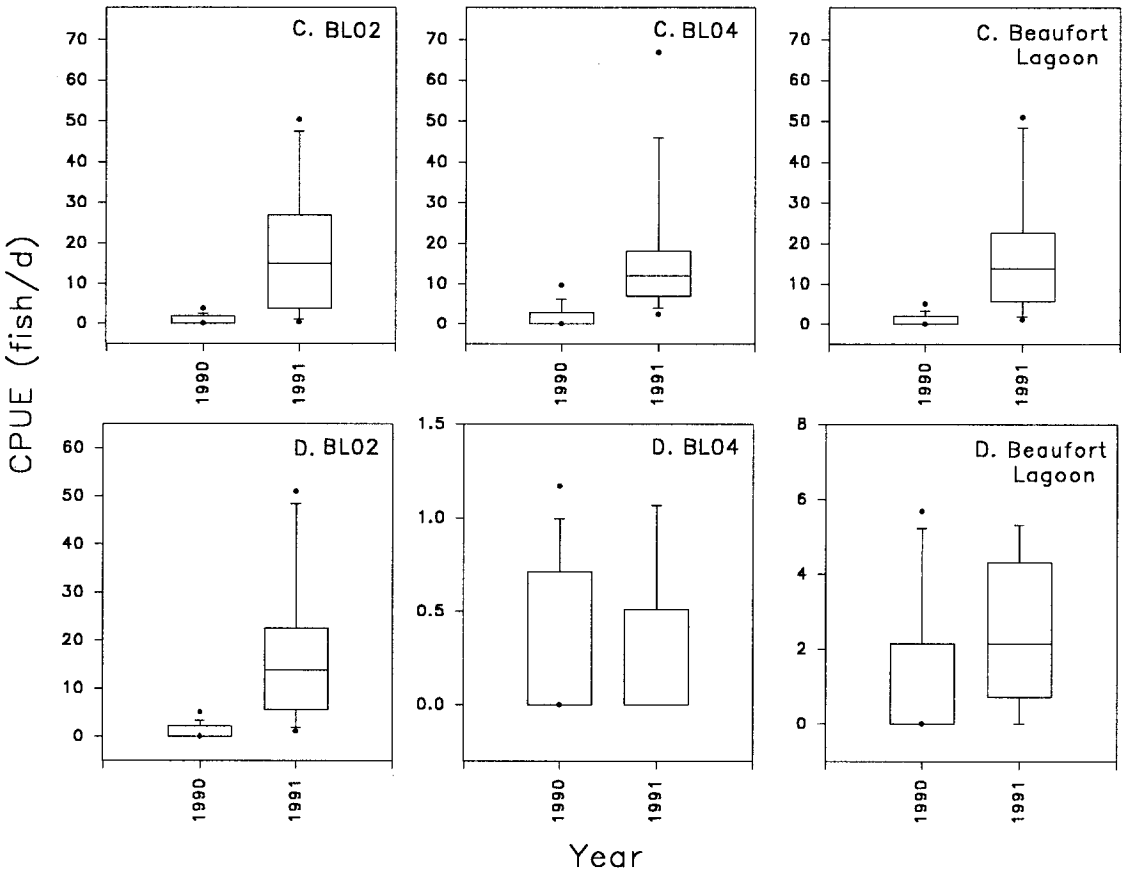

FIGURE 2.29.– Boxplots comparing daily CPUE (fish/d) observations between years for Dolly Varden char in Beaufort Lagoon. C = time period 3, August 15 to August 31. D = time period 4, September 1 to the last sampling day.

daily catch rates at net stations SC04, 1990 and 1991, and JL12, 1989 and 1991. The lowest daily catch rates occurred at net station SC04 in 1988 and 1989, at net station SC01, and in 1989. In 1990 we observed some of the lowest daily catch rates for Dolly Varden char at net stations KL05, KL10, BL02 and BL04. At net station JL12 daily catch rates did not differ significantly between 1988 and 1990. No significant differences were detected between daily catch rates for 1988, 1989, and 1990 at net station JL14.

In all sampling areas, we documented the highest daily catch rates for Dolly Varden char in 1991. In Simpson Cove daily catch rates did not differ between 1988 and 1990, with 1988 catch rates being the lowest. Daily catch rates in Kaktovik Lagoon did not differ between 1989 and the remaining two years. Jago Lagoon daily catch rates did not differ between 1990 and the preceding two years. Beaufort Lagoon daily catch rates were lowest in 1990.

Between-year comparisons within time periods, by locations, suggested high daily catch rates during 1991. For the Simpson Cove sampling area, with net stations SC01 and SC04 (excluding time period 4), 1991 was one of the years with the highest catch rates (Table 2.9; Figures 2.22-2.23). Net stations at Kaktovik Lagoon, KL05 (excluding time period 4) and KL10, also had their highest catch rates in 1991 (Table 2.10; Figures 2.24-2.25). During time period 4 at net station KL05, no significant differences were detected between years. During time period 1 at net stations JL12, JL14, and the Jago Lagoon sampling area the 1991 daily catch rates are again among the highest (Table 2.11; Figures 2.26-2.27). During time period 2 at net station JL12, daily catch rates did not differ between the four years. Whereas at net station JL14 and in the Jago Lagoon sampling area daily catch rates did not differ between 1988 and 1989, or between 1990 and 1991. At all Jago Lagoon locations, we found no significant differences between daily catch rates for 1988-91 during time periods 3 and 4. Excluding daily catch rates during time period 4 at net station BL02, the Beaufort Lagoon sampling area 1991 catch rates were higher than those for 1990 (Table 2.12; Figures 2.28-2.29).

Length Frequency Distributions

Overall trends of Dolly Varden char length frequency distributions generally showed annual unimodal or bimodal patterns in each of the four time periods (Figures 2.30-2.38). Modes generally occurred at two length intervals, between 200-260 mm FL and 340-380 mm FL. Some sample sizes in Beaufort and Pokok lagoons were too small to determine distribution patterns (Figures 2.36-2.38).

In Simpson Cove a distinct mode occurred around 200 mm FL in all years during the first sampling period, July 9 to 31. During the other three sampling periods (August 1 to September 14) and four years the mode had shifted to the right to 240-260 mm FL (Figures 2.30-2.32). No distinct bimodal patterns were apparent during August 15 (Figure 2.30A-H). Length frequencies in Kaktovik Lagoon indicated both unimodal and bimodal distributions. During the first sampling period for all years, primary modes in frequency occurred at 200 mm FL in 1988 and 1991 and at 240 mm FL in 1989 and 1990 (Figure 2.32). These modes were weak in 1990 and 1991. Secondary modes occurred between 300 and 400 mm FL (Figure 2.33). During the other

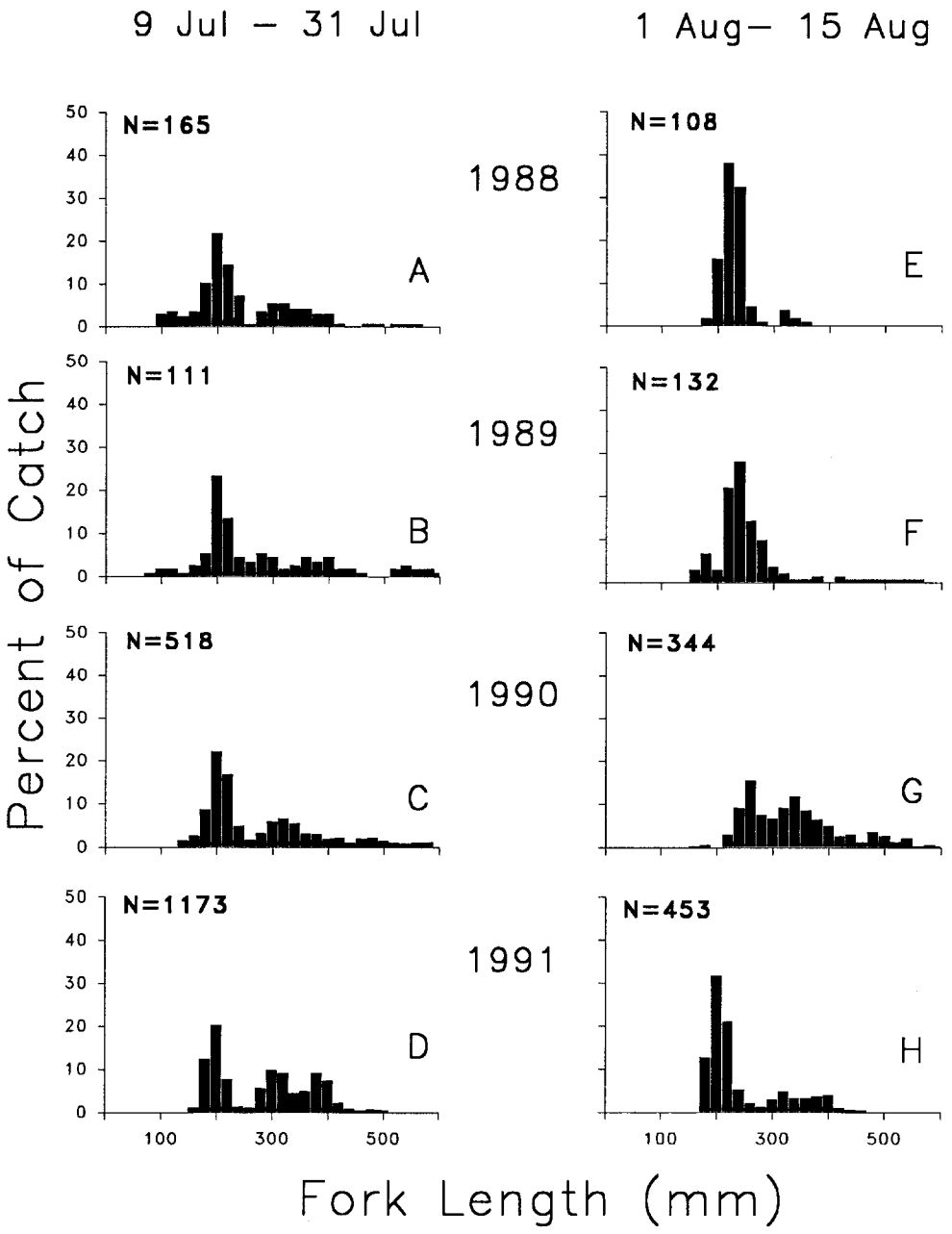

FIGURE 2.30.– Length frequencies of Dolly Varden char captured by fyke nets in Simpson Cove, plotted by year for July 9 to August 15.

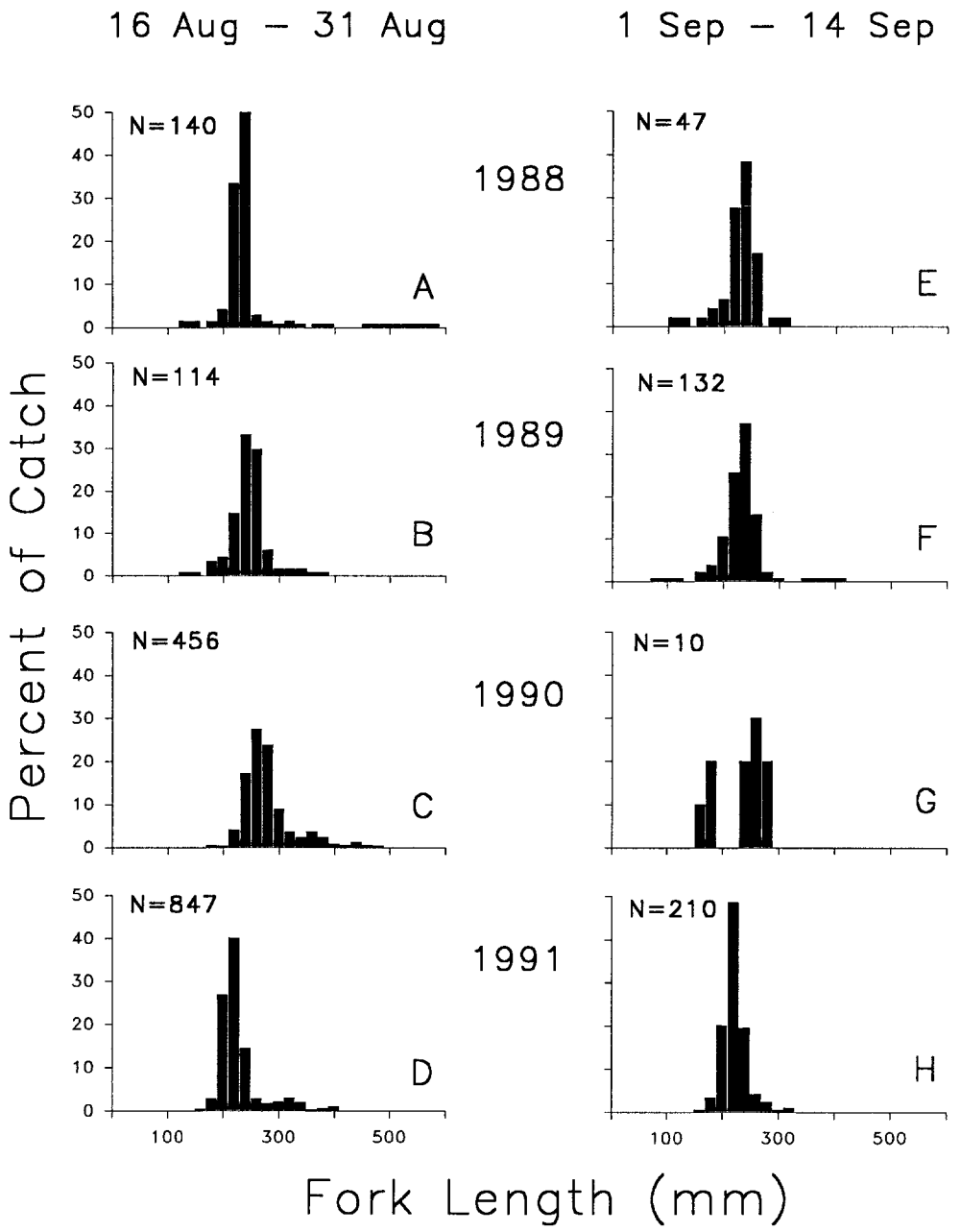

FIGURE 2.31.– Length frequencies of Dolly Varden char captured by fyke nets in Simpson Cove, plotted by year for August 16 to September 14.

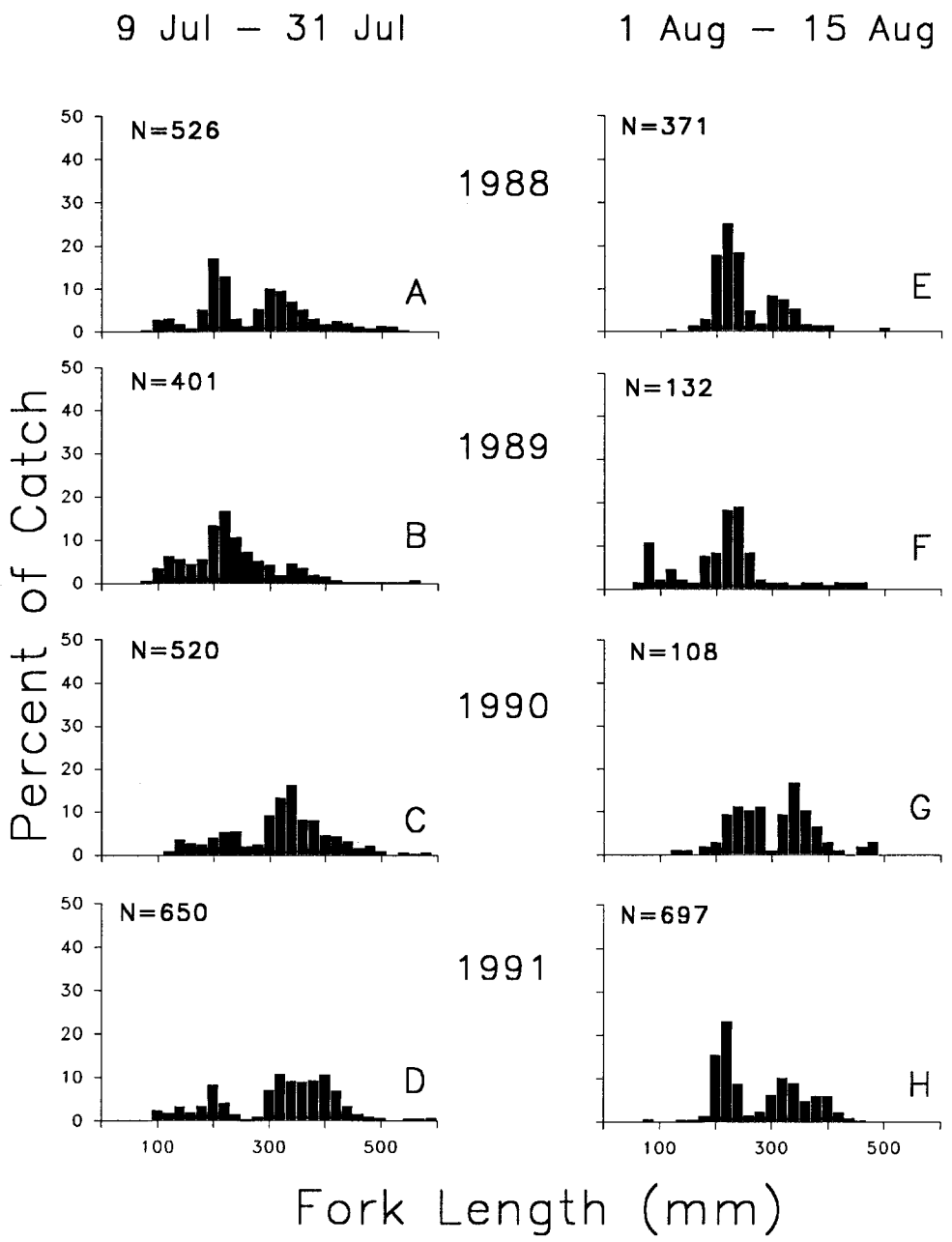

FIGURE 2.32.– Length frequencies of Dolly Varden char captured by fyke nets in Kaktovik Lagoon, plotted by year for July 9 to August 15.

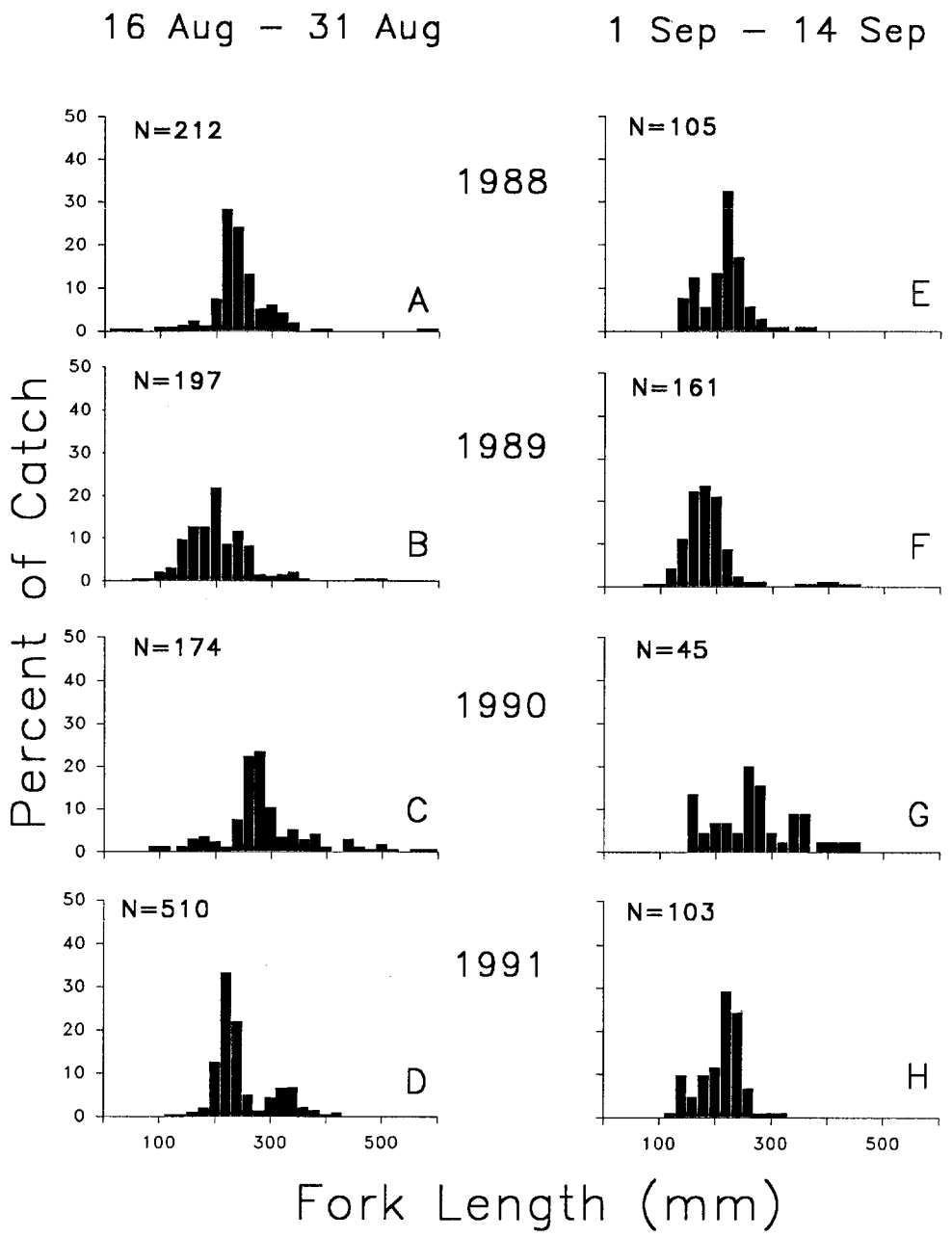

FIGURE 2.33.– Length frequencies of Dolly Varden char captured by fyke nets in Kaktovik Lagoon, by year for August 16 to September 14.

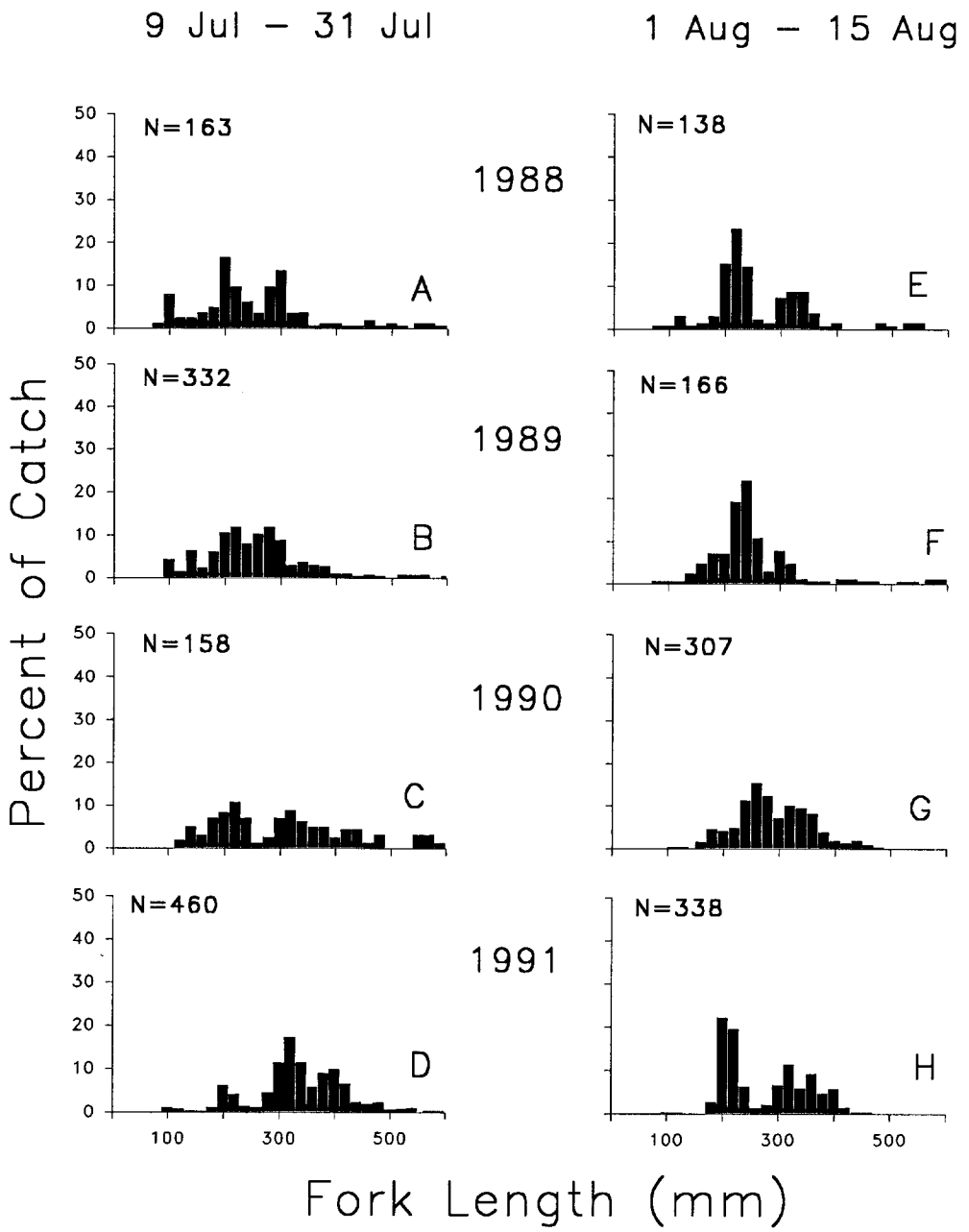

FIGURE 2.34.– Length frequencies of Dolly Varden char captured by fyke nets in Jago Lagoon, plotted by year for July 9 to August 15.

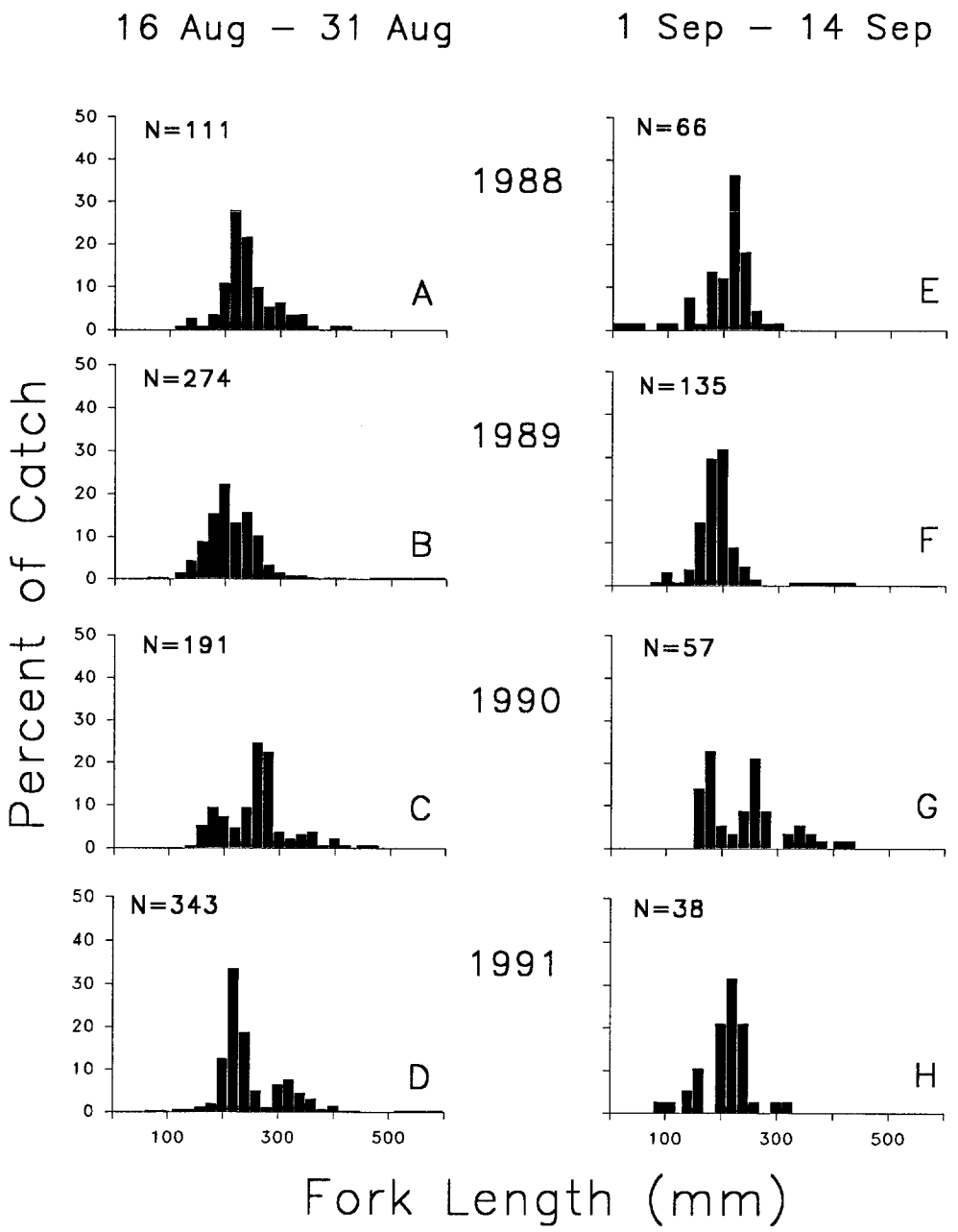

FIGURE 2.35.– Length frequencies of Dolly Varden char captured by fyke nets in Jago Lagoon, plotted by year for August 16 to September 14.

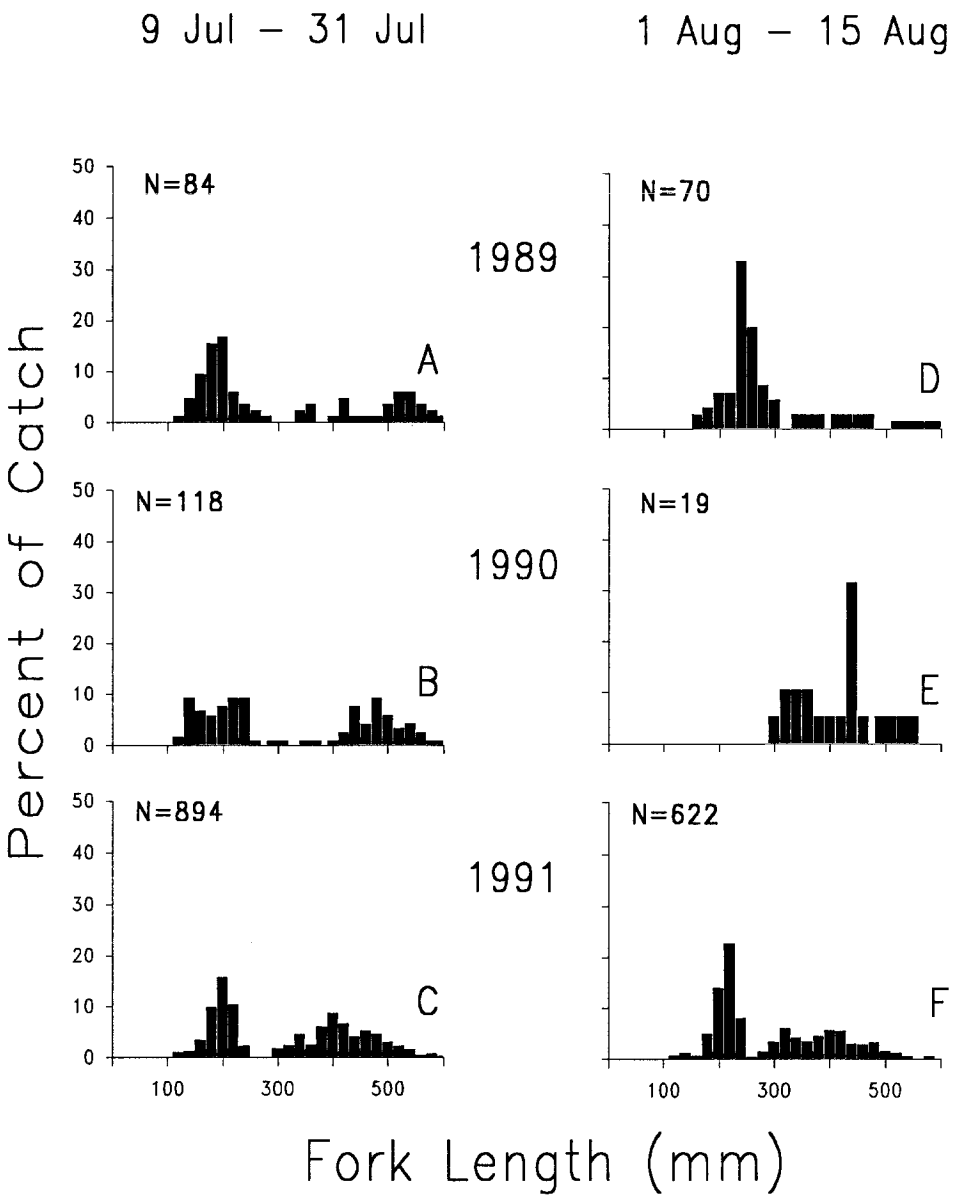

FIGURE 2.36.– Length frequencies of Dolly Varden char captured by fyke nets in Beaufort Lagoon, plotted by year for July 9 to August 15.

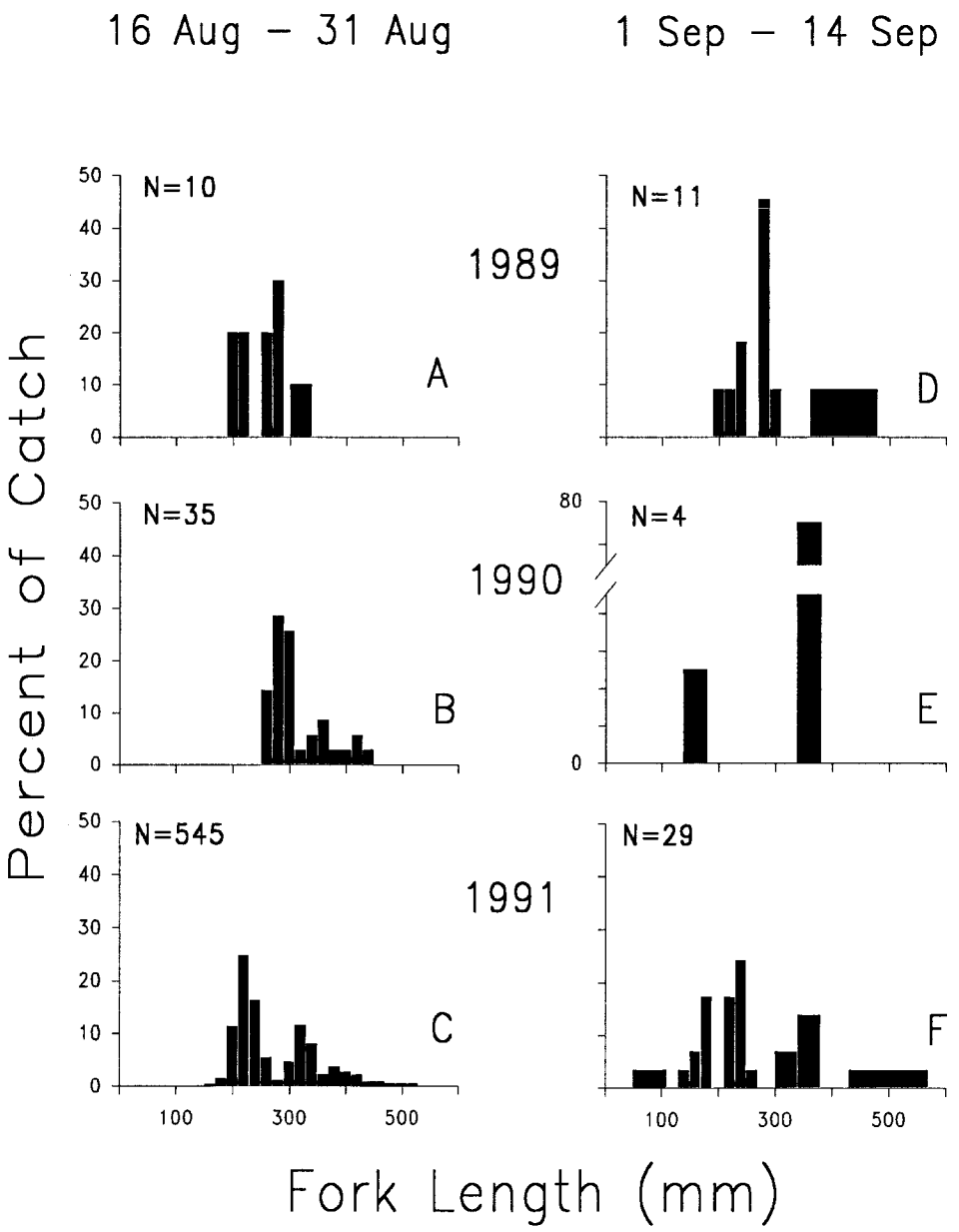

FIGURE 2.37.– Length frequencies of Dolly Varden char captured by fyke nets in Beaufort Lagoon, plotted by year for August 16 to September 14.

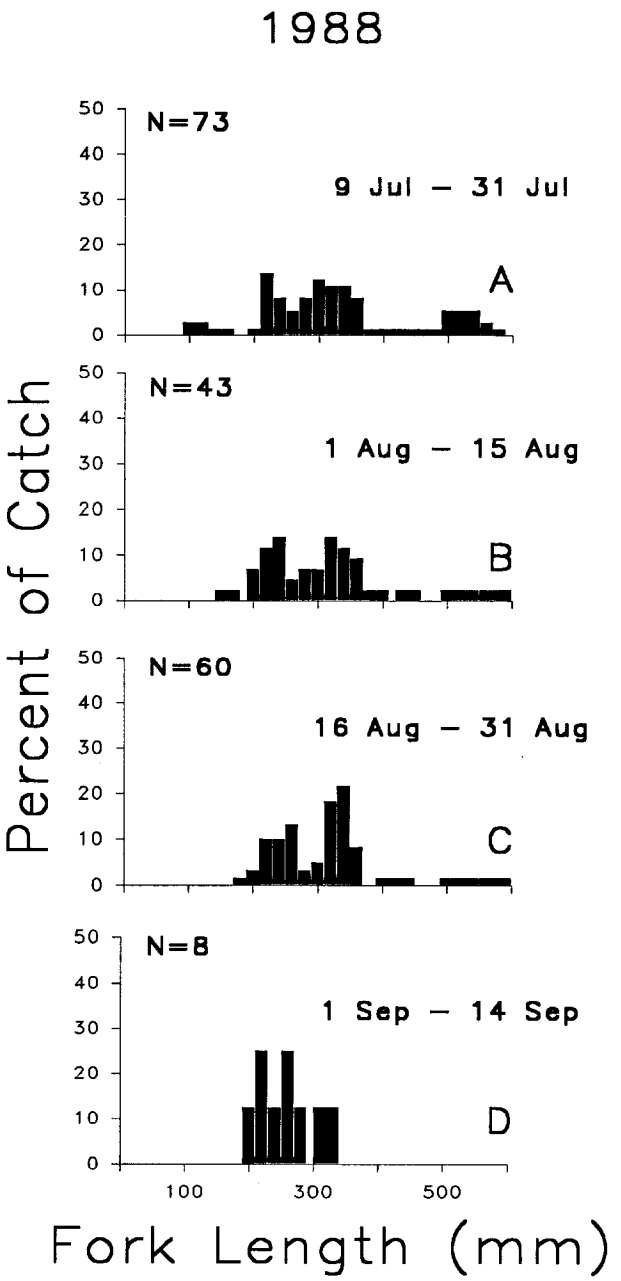

FIGURE 2.38.– Length frequencies of Dolly Varden char captured by fyke nets in Pokok Bay, plotted for July 9 to September 14, 1988.

three sampling periods for all years, the modes were strongest at lengths between 240 and 280 mm FL (Figures 2.32-2.33).

In Jago Lagoon, early sampling yielded modes at 200 mm FL in 1988 and 1989, at 240 mm in 1989 and 1990, and a very small mode at 200 mm FL in 1991 (Figure 2.34). By August 1, the modes had increased by 40 mm FL except in 1991 when the primary mode remained at 200 mm FL (Figure 2.34). During the third and fourth sampling periods (August 16 to September 14), the modes remained steady at 200 mm (1989), 240 mm (1988 and 1991) and 260 mm FL (1990) (Figures 2.35).

In Beaufort Lagoon, we observed bimodal distributions during the first sampling period (Figure 2.36). Primary modes during this time ranged between 120 and 240 mm FL and secondary modes occurred at lengths > 400 mm FL. During the third and fourth sampling periods, modal determinations were difficult due to small sample sizes in 1989 and 1990. In 1991, two modes occurred at 240 and 340 mm FL (Figure 2.37).

Pokok Bay, sampled only in 1988, showed primary modes at around 240-280 mm FL until August 31 and secondary modes around 340 mm FL (Figure 2.38). Low sample sizes during the fourth period excluded it from examination.

Condition

Gender differences.— We did not detect significant differences between the condition of female and male Dolly Varden char (slope, $P = 0.69$; intercept, $P = 0.96$) when suitable data from all years were combined (Table 2.13). When outliers were discarded we obtained similar results. Plots of transformed data indicated fewer small males than females (Figure 2.39A-B). Within individual years, we did not detect differences between sexes. In 1988, when outliers were discarded, results were very close to significant (intercept, $P = 0.051$).

Seasonal differences.— Differences in slope ($P = 0.007$) precluded direct statements about changes in condition for fish captured in July (early) versus those collected after August 27 (late) using data from all years combined (Table 2.14). Plots of transformed data showed differences; the late sample included more very small and fewer very large fish (Figures 2.39C-D). Removal of outliers did not change the results of the analysis. During 1988 and 1991, differing slopes also interfered with condition analyses. In 1990, we found no differences in parameter estimates. We found differences in condition only in 1989. Slopes were similar ($P = 0.50$) while intercepts differed ($P = 0.0001$) slightly (Table 2.14). Our data suggest that fish weighed less at a given length at the end of the open water season in 1989.

Overwintering.— Between time periods used to examine the winters of 1988-89 and 1990-91, we detected differences in slope which precluded statements about condition (Table 2.15). However, slopes were similar ($P = 0.66$) and intercepts ($P = 0.0004$) differed significantly in the winter of 1989-90. The intercepts indicated that condition increased slightly over the course of the winter. Plots of transformed data indicated fewer large and small fish during

TABLE 2.13.– Condition comparisons between female and male Dolly Varden char collected in July. Analyses were for combined years and within an individual year. Asterisks (*) indicate significant differences in condition.

		Slopes		Intercepts		
Group	*N*	*b*(SE)	*P*-values	$\log_e a$(SE)	*P*-values	r^2
			All years			
Females	285	3.07 (0.02)		-12.09 (0.10)		0.99
Males	146	3.06 (0.02)		-12.03 (0.13)		0.99
	Without outliers		$P = 0.69$ $P = 0.72$		$P = 0.96$ $P = 0.87$	
			1988			
Females	124	3.11 (0.03)		-12.32 (0.19)		0.99
Males	86	3.12 (0.04)		-12.37 (0.22)		0.99
	Without outliers		$P = 0.82$ $P = 0.85$		$P = 0.09$ $P = 0.051$	
			1991			
Females	130	3.05 (0.02)		-11.98 (0.11)		0.99
Males	51	3.01 (0.02)		11.80 (0.13)		0.99
	Without outliers		$P = 0.33$ $P = 0.35$		$P = 0.22$ $P = 0.11$	

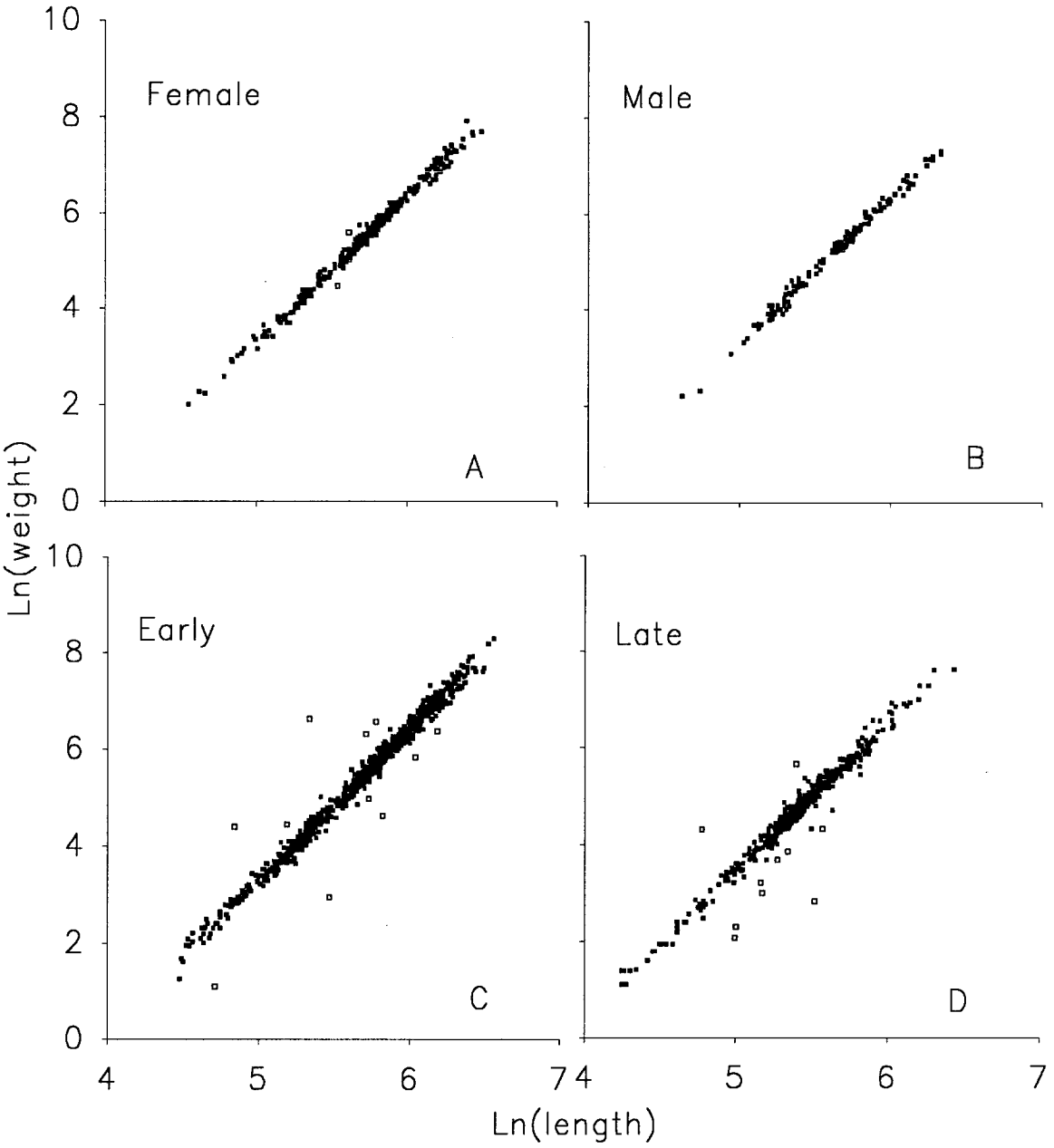

FIGURE 2.39.– Log-transformed weight-length data (□=outliers) for comparisons between sexes (A,B) in July and between seasons (C,D). Seasonal data correspond to early (July 9-31) and late (August 27-September 14) sampling periods.